

**INVESTING
IN HUMAN
POTENTIAL:**

*Science and
Engineering
at the
Crossroads*

EDITED BY MARSHA LAKES MATYAS AND SHIRLEY M. MALCOM
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

**Investing in Human Potential:
Science and Engineering
at the Crossroads**

Edited by
Marsha Lakes Matyas
and
Shirley M. Malcom

American Association for the Advancement of Science
Washington, DC

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Executive Summary

In 1989 at the Education Summit in Charlottesville, the President and the nation's governors agreed upon six goals for education to be achieved by the turn of the millennium. Included among these was the goal that the United States be first in the world in science and mathematics achievement by the year 2000. One of three objectives embedded within this goal is the need to increase significantly the participation of women and minorities in science and engineering careers. In the same year, the Congressionally-mandated Task Force on Women, Minorities and the Handicapped in Science and Technology made recommendations to various segments of the educational and policy communities for actions to be undertaken to increase the participation of women, minorities, and people with disabilities in science and engineering (Task Force 1989).

While much of the spotlight of educational reform has been on K-12 science and mathematics education, it is clear that the objective of expanding the base of participation in science, mathematics and engineering can only be achieved by extending the reform efforts to the nation's colleges and universities. This study examined the efforts made by U.S. higher education institutions to increase the participation of women, non-Asian minorities, and people with physical disabilities in science and engineering. Through surveys of the presidents/chancellors of 276 colleges and universities, the directors of nearly 400 recruitment/retention programs, and of nearly 100 disabled student services offices established by those colleges and universities, intensive case studies of a smaller set of institutions, information concerning the goals and methods of programs, and the policies and practices of the institutions were obtained and analyzed. Findings and recommendations for programs targeted at women and minorities, services targeted at people with physical disabilities, and institutional policies and practices are summarized below.

Programs for Women and Minorities

Summary of Findings

The results of the current study reconfirm those of previous studies; few programs directly target female students or faculty. In fact, less than 10% of the programs in the current study were specifically focused on the recruitment and retention of women in science or engineering. Programs for women were more likely to charge fees for services and to rely heavily on the use of faculty volunteers. Similarly, the number of efforts targeted toward graduate students and faculty members were extremely limited in both number and kind. Graduate efforts were primarily in the form of recruitment and/or financial support rather than interactive support programs. Faculty programs also focused heavily on recruitment, but few had any activities to support the "integration" of the new faculty member into the department or to promote mentoring by more experienced colleagues.

Even at the precollege level, only about half of the programs at colleges and universities involved parents of students. Less than a third of undergraduate science/engineering programs did so.

Programs involved large numbers of Black students, moderate numbers of Hispanic students, and limited numbers of American Indian students. Programs targeted at minorities did a good job of involving Black females in program activities, but Hispanic and American Indian females were less likely to be involved. Programs for women have not been as successful in recruiting minority females into their activities. The staff at most of the programs reflected the racial/ethnic groups and sex of the program participants.

Intervention programs generally used a variety of strategies and activities to achieve their goals. Not all strategies and activities are equally valuable. Instead, the goals of the program, the resources available, and the target group of participants determined the particular components included in a program.

A stable funding base is critical to the continued existence of an intervention program. Some programs mainstreamed activities into the regular activities of the host institution and, therefore, relied primarily on the institution as a source of support while other programs, especially science/engineering programs, relied on external funds. In order to promote participation by diverse participants, very few programs charged fees of their participants even though finding support to finance student participation was difficult.

Programs targeting women were the exception; they were more likely than other program types to charge fees of their participants. Providing financial support for students was a key element in the success of many programs, especially those serving graduate students. Most programs relied on a single funding source. Unless these programs continue to be successful in maintaining this source of funding, their survival is at risk.

Although evaluation is a basic component of program development and implementation, only half of the programs in this study had completed even a general evaluation of their program's effectiveness.

Most program staff felt that they had strong support from top administrators and department heads. Perceived support from faculty members was somewhat lower. While one-on-one interaction with faculty members was cited as one of the most successful strategies used in many programs, it was also perceived as very time consuming for both faculty and program staff. Participation in intervention programs can create special problems for science/engineering faculty members, especially those who are female and/or minority, since they are often asked to work with multiple programs and serve on multiple committees—activities which can absorb much of their time allotted for research activities.

Recommendations

- A rejuvenation of efforts to recruit and retain women in science and engineering is needed. Effective program models and materials are abundant, but dissemination of these models must be funded. Program models, materials, and dissemination methods must be evaluated. Similarly, program models for recruiting and retaining female and minority graduate students and faculty members in science and engineering are desperately needed.

- The involvement of parents and "significant others" in efforts targeted toward students is critical, even at the graduate level. Programs should make efforts to help parents understand how and why students become scientists and engineers, how the program activities can assist students in reaching their goals, and how parents and "significant others" can assist the student in this process.
- In general, programs must expand their recruitment efforts into new areas. Precollege and undergraduate programs must establish relationships with community-based organizations such as youth groups and churches. All programs must make special efforts to recruit and retain American Indian students in science and engineering, especially at those institutions that serve a significant American Indian student population. Programs targeted at women must make efforts to recruit more minority women, especially Hispanic women, into their programs. Graduate and faculty programs must establish ongoing partnerships with administrators and science and engineering faculty at higher education institutions that serve large proportions of minority students to develop a pipeline of minority graduates interested in their programs. In the case of identifying and recruiting female and minority faculty members, institutions may need to develop relationships with potential faculty members early—during or prior to their entrance into graduate school. In general, recruitment efforts must reach far back into the educational pipeline and promote the development of students.
- Programs employ a variety of successful strategies and activities to achieve their goals. Some of the most effective are also the most costly and staff-intensive. Certain strategies are hallmarks of effective programs and should be incorporated where possible. These include: (1) using hands-on (laboratory), inquiry approaches, and cooperative group work as opposed to lecture and discussion; (2) structuring programs targeted at women like those for minority students, including multi-year involvement with students, strong academic components, increased daily/weekly contact with students, and reducing the number of programs that charge fees; (3) providing residential campus experiences such as overnights, summer programs, and bridge programs; (4) assuring that one-time outreach programs for generating interest in science and/or engineering include activities for parents and teachers as well as for students, have a specific focus on sparking interest among female and/or minority students, and are accompanied by follow-up activities for students; and (5) assuring that mechanisms are in place to promote departmental commitment to the success and continued support of female and/or minority graduate students who receive targeted fellowships.
- The racial/ethnic group, sex, and job responsibilities of the program staff should provide role models for not only the current program participants but for those the program hopes to attract, as well. For example, programs targeted at women should include persons of diverse racial/ethnic groups as administrators, support staff, and program volunteers.

- Programs should develop a stable funding base either by mainstreaming program components into the overall activities of the host institution and, therefore, becoming a regular budget item for the institution or, in the short term, by developing a diverse group of external funding sources. Programs should avoid participant fees whenever possible, and funding should be provided by the institution to assure that financial need does not prevent participation in programs by women and minorities.
- Evaluation must be integral to intervention programs, not an "add-on" at the program's completion. Specific program goals should be set and evaluation methods designed to assess those goals. Funding agencies and institutional administrators should require program directors to provide evidence that specific program goals have been set, a detailed plan of evaluation has been constructed, and a regular method for reporting evaluation results has been established.
- Faculty involvement in intervention programs is critical to their success; therefore, involvement should be encouraged. However, it must also be rewarded. Participation in program activities should be counted in the tenure and promotion process along with research productivity and teaching. Similarly, female and minority faculty members should be encouraged and supported to balance research, teaching, and intervention activities while minimizing committee involvements in their first years.

Services for Students with Physical Disabilities

Summary of Findings

U.S. colleges and universities will face new challenges in meeting the requirements outlined by the 1990 Americans with Disabilities Act. The information provided by this study indicates that the specific needs of science and engineering students with physical disabilities require additional attention from these institutions. For students with physical disabilities, there is rarely a specific program focused on removing barriers and smoothing their path to a career in science or engineering. These students are unlikely to encounter a science or engineering role model in junior high or senior high school, and there is seldom a career fair for students with physical disabilities. Students with physical disabilities, unlike female and minority students, are not specifically targeted by science/engineering recruitment programs at colleges and universities. For these students, the disabled student services office (DSS) is the primary source of help.

Students are more likely to find a full-scale, centralized disabled student services office at a Research University, Doctorate-Granting Institution, or Comprehensive College or University than at a Liberal Arts College or Professional College/University. Smaller institutions, such as Liberal Arts Colleges, often distribute DSS functions among several campus offices. This study does not distinguish between the quality of one method versus another; each has its advantages and disadvantages.

While these offices are responsible for serving the needs of students with physical and learning disabilities in a wide variety of major fields of study, they often operate on low budgets and with limited paid staff. In general, these

offices do not do any outreach activities to K-12 students or parents. They focus on their mission of serving registered undergraduate and graduate students, faculty, and staff who request assistance.

Students with physical disabilities who major in science or engineering may find that the DSS at their institution has not encountered their specific needs before, especially in laboratory courses or when specific technologies or services are required. In general, the offices are willing to try to accommodate each student's needs but, in many cases, the student will have to put forth considerable effort to prepare the classroom, the professor, and the needed equipment or modifications prior to entry into the specific course. In some cases, the student is financially responsible for these accommodations as well. For all students, personal attention, mentoring, and nurturing the development of self-esteem are important factors in the student's success in higher education and beyond. For students with physical disabilities, the presence or absence of these factors through DSS offices, within their academic departments, and in on-campus housing can be critical in their success.

Recommendations

- Science and engineering departments and staff of DSS offices must make a clear commitment to providing students with physical disabilities full access to training in these fields. This requires that both the department in which the student is enrolled and the DSS take an active role in determining that a lack of needed equipment, interpreters, or other services will not act as a functional gatekeeper, preventing the student from making normal progress toward his/her educational goals. Departments (or institutions in a geographic area) may be able to generate a pool of adapted equipment available for check-out or rental during semesters when it is needed. Similarly, specific efforts must be made to recruit and retain science and engineering faculty members who come to the institution with a physical disability or acquire a physical disability while at the institution.
- Science and engineering faculty and graduate teaching assistants need to have some understanding of the rights and potential needs of students with physical disabilities who may be enrolling in their courses. The best time for this information to reach the faculty and graduate students is before the student arrives for class. This information should be available as printed material and should be presented during a departmental seminar and/or during required orientation sessions for graduate teaching assistants.
- With assistance from the DSS staff and staff of national organizations such as AAAS, science and engineering departments could assess laboratory facilities, course software, hardware, equipment, and classroom facilities specifically for accessibility and possible adaptation. Likewise, faculty who direct graduate studies could be provided with guidelines and suggestions for creating an accessible research laboratory setting. Plans of action for creating an accessible department should be drawn and work begun. Departments both within and among institutions should share their findings and ideas.

- Because the doors to a future career in science and engineering can be closed early in adolescence, science and engineering departments, DSSs, and other university departments should form coalitions with area community-based organizations to provide outreach activities to children in grades K-12 who have physical disabilities. In addition, outreach activities should include parents of these children. These efforts may require external funding by agencies such as the National Institutes of Health or National Science Foundation or by private foundations or businesses.
- Institutional outreach activities should promote science and engineering education for students with disabilities. Science and mathematics institutes for K-12 teachers should include adaptation issues as a focus for discussion and in materials development. Outreach activities through the admissions office or other departments should be accessible, and their accessibility should be well-publicized through appropriate routes.

Institutional Policies and Practices

Summary of Findings

Responses to the "Survey of Presidents and Chancellors" provided an overview of some of the major institutional characteristics which can affect the recruitment and retention of underrepresented groups in science and engineering. These included tuition rates and the availability of financial aid; flexibility in declaration of major field of study; campus policies which address sexual harassment, training for graduate student teaching assistants, and access to services and physical facilities for students with disabilities; the availability and status of faculty members who can act as science/engineering role models for target group students; and the monitoring of student progress in science and engineering. The data provided by the participating institutions indicate that there are differences among the various institutional types in how they approach the problem of recruiting and retaining underrepresented groups in science and engineering. However, some of the findings suggest recommendations for action which should be useful to all institutions. These general findings and recommendations are described below.

Nearly all of the institutions in this study had a stated policy on sexual harassment. Many larger institutions had conducted studies of campus accessibility to students and faculty with physical disabilities, but studies on campus climate for women and minorities were less common. Although most institutions that have graduate student teaching assistants provide some type of training sessions for them, their impact on campus climate for women, minorities, and people with physical disabilities remains unclear.

With the exception of women's colleges and minority institutions, women and minorities continue to be underrepresented on science and engineering faculties. This is true even among the institutions in the current study—institutions that have good track records of equity efforts in this area. This is especially true for Research Universities and at the highest level faculty positions. The lack of information on the presence of faculty members with physical disabilities leaves their status unclear.

Although attrition and retention in science/engineering are often the subject of studies in higher education and are of obvious financial concern for higher education institutions, few institutions routinely monitor the attrition/retention of groups that are particularly at risk.

In summary, previous studies have shown that creating an atmosphere which promotes diversity among the science and engineering faculty and student body requires a focus on many aspects of both academic and social life on campus. The current study suggests that the approach an institution takes toward creating an atmosphere for diversity may differ by institutional type. Regardless of the specific strategies used, however, institutional commitment is the required first step.

Recommendations for Practice

- Institutions should examine both the amount and type of financial aid received by science and engineering students by racial/ethnic group, by sex, and by physical disability. In addition, special consideration should be given to students who carry a heavy load of laboratory course work which requires more in- and out-of-class laboratory time. The nature of the science/engineering curriculum may make it difficult for students to put in adequate paid-work hours to supplement their financial aid.
- Institutions should reduce the rigidity of the science and engineering curriculum to allow "undecided" students, or those in other major areas of study, to switch into science or engineering studies.
- Institutions that have not already done detailed studies of accessibility and campus climate should do so. Those institutions that have already conducted general access studies should initiate specific studies to examine access to science/engineering classrooms, laboratories, and equipment and intervention programs.
- The number of females, minorities, and persons with physical disabilities on science/engineering faculties must increase. Aggressive recruitment, development of female and minority graduate students and postdoctoral fellows, mentoring programs, and general support for new female and minority faculty members must all be utilized in this effort.
- Institutions and specific science/engineering departments should monitor carefully the progress of students, especially female and minority students and those with physical disabilities, to determine where attrition is occurring. Further, careful analysis may be warranted to determine the causes of those losses.

Federal Support of Research and Human Resources

A recent report from the Office of Technology Assessment recommends the introduction of additional criteria in research funding decisions, such as in considering human resources, education, economic development and diversity implications of support. This strategy argues for affecting the structure of federal funding for research and development at colleges and universities.

Federal funding for research and development also can help to leverage structural change to develop a system that supports the participation of women, minorities, and people with disabilities such as by affecting the opportunity for undergraduate research participation, the support of graduate students and the nature of the undergraduate curriculum. While most of the recommendations for improving the conditions for women and minorities are most appropriately directed to the institutions themselves, there is much that the federal government can do through its funding mechanisms to encourage and support the development of human resources for science and engineering.

- The research capability of institutions with a proven record of developing students from underrepresented groups must be supported. Programs such as MARC, MBRS, and Minority Research Centers of Excellence, should be continued and expanded to enhance the research environments of institutions with proven track records in the education of minority students in science and engineering. Similarly, there is a need to explore the possibility of establishing similar research-focused programs for historically women's colleges.
- Scholarship support should be provided for students from underrepresented groups to encourage participation and retention in science and engineering fields. Scholarships inform the research establishment about federal government priorities for the U.S. research enterprise. When used in conjunction with program support activities, scholarships can be an effective tool to build a cadre of talented and committed students for science and mathematics who come from underrepresented groups, especially those that require commitment to and build toward graduate and/or professional education in engineering and science-based fields.
- The effectiveness of portable and institutionally based sources of graduate support for minority students should be evaluated and the funding of models that seem to be most effective in supporting the development of these students in science and engineering must be greatly increased. Federal and non-federal support programs should be included in this effort. Many have argued that the effectiveness of the GEM program (National Consortium for Graduate Engineering Degrees for Minorities) is due to its program structure, which balances portability, requirements for institutional commitment, and ties to the work force.
- Programs of graduate support for female and disabled students should be established and current support mechanisms for graduate education monitored to ensure that students from underrepresented groups have access to research assistantship funding. Targeted programs are still necessary to support the movement of students from underrepresented groups through the science and engineering pipeline. One can argue that the regular mechanisms for support of graduate education must be made more accessible to such students so that targeting ceases to be necessary. More careful monitoring should be made of the race, ethnicity, sex, citizenship, and disability status of students being supported through assistantships tied to research grants.

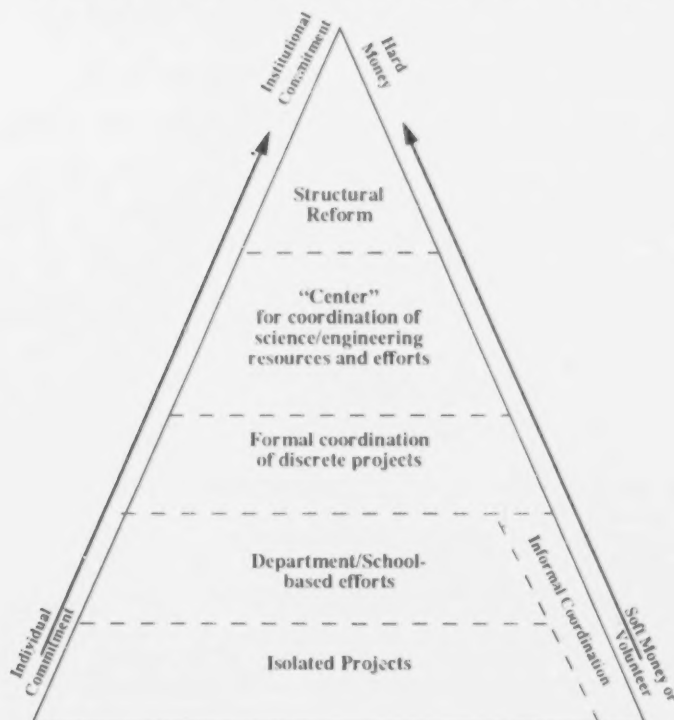
- Access to programs and institutions by underrepresented groups must become a major criterion to determine merit in evaluating proposals for establishing major research centers or for renewing contracts or cooperative agreements for existing centers. As the demand grows for research funds, institutions should be required to demonstrate that major federal research investments will be accessible to all students through pro-active efforts to include minority, female, and disabled students among those participating in research and training activities. An additional criterion should be the current status of women, minority, and disabled faculty, and historical evidence of progress in attracting and advancing such individuals.
- Enhanced collection of data by colleges and universities to provide indicators of participation in science and engineering by race/ethnicity, sex, and disability status should be encouraged and supported. Determining the health of science and engineering depends on being able to assess the flow of people through the pipeline for these fields. Current levels of data collection are not adequate to do this. Especially lacking is information on the retention of students in science and engineering, especially by race/ethnicity and sex. The notion of retention rate in graduate education in science and engineering does not appear to operate, but the conversion of graduate school enrollees to graduates is an important indicator of the "health of science." More study is needed on this missing information to assess the status of graduate education. Without it there is little hope of even identifying, much less plugging, these leaks from the pipeline.
- Federal support should be provided for a range of program structures to address underrepresentation in science and engineering at undergraduate and graduate levels. Successful efforts should be disseminated, and the emphasis of funding should be shifted from isolated projects to institution-wide, coordinated efforts that can effect structural change. Even case studies of strong institutional responses confirm the absence of models of structural reform within colleges and universities to support the participation of underrepresented groups.

Looking Past the Crossroads: The Future of Intervention

Most of the interventions devised by colleges and universities are aimed at enabling students and/or faculty from underrepresented groups to fit into, adjust to, or negotiate the existing system. There is little challenge to the structures that currently exist. A coherent, coordinated, articulated structural approach to enabling students from underrepresented groups to succeed in science, mathematics, and engineering programs has yet to be achieved by the institutions. Within the special project structure, which is the most common intervention strategy, we find that these models support enhanced learning for all students, not only for the underrepresented students for whom they may have been originally designed. Perhaps programs for women, minorities, and students with disabilities can once again point the way toward structured reform within science, mathematics, and engineering programs that can provide excellent education for everyone.

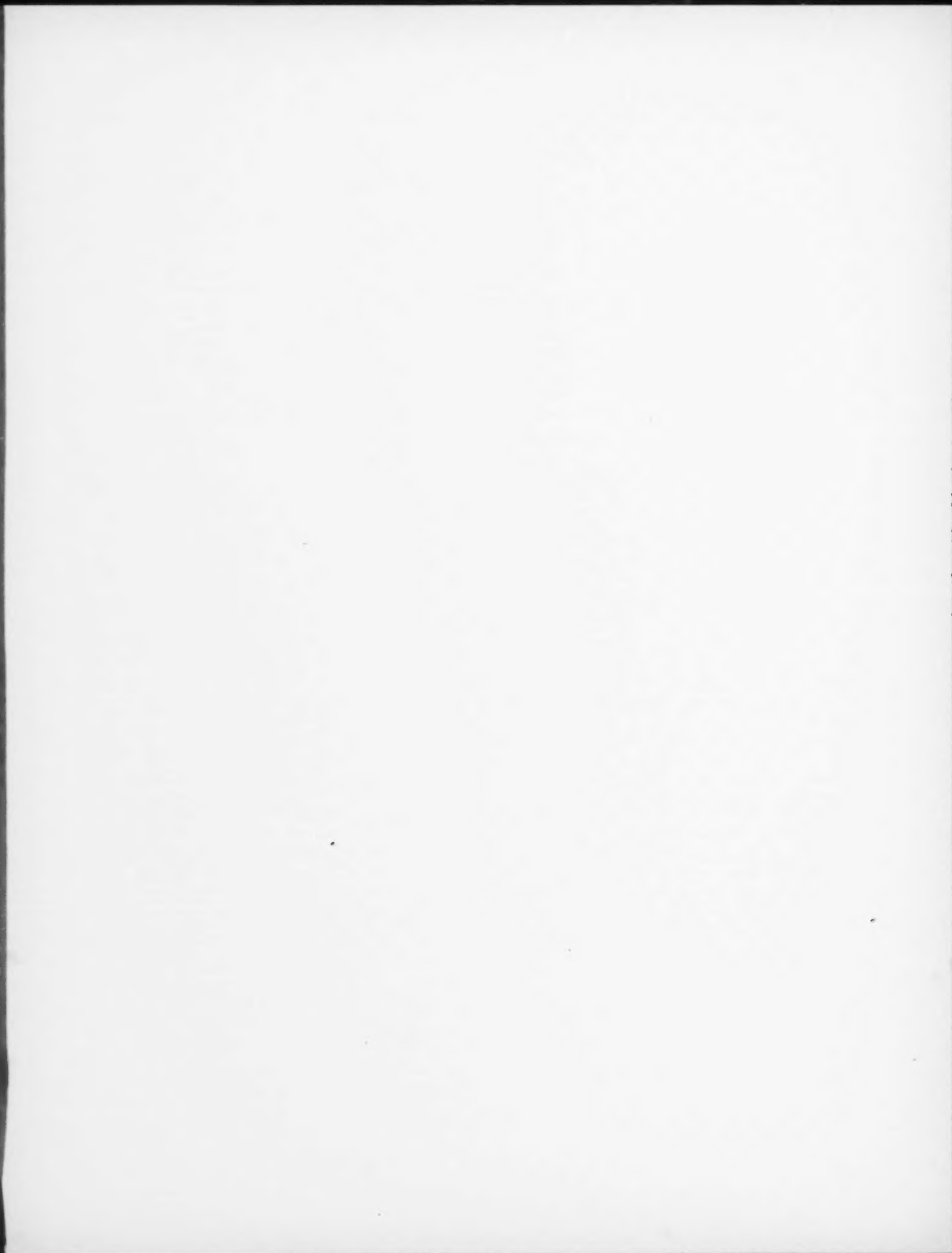
Based on project descriptions and case studies, a model for the evolution of intervention programs was developed. This model includes five levels, ranging from isolated projects or programs to structural reform. The intervention efforts of most institutions was at the isolated projects level where programs and projects were not connected in any way and relied primarily on soft money for support. In a few instances, institutions created centers for the coordination of large parts of the process of recruiting, retaining, tracking, and advancing students to graduate education (Level Four). Not found among any of the institutions was a model of structural reform where the structure of courses, pedagogical techniques, institutional climate, and system for recruitment and retention co-existed with a supportive administrative structure, that is, where the regular support of departments and programs provided mechanisms to support the achievement of all students committed to education in science and engineering. Only by moving from ancillary activities aimed at helping students survive the current educational climate to changing the climate in which the students are educated can we reach the goal articulated by the President and the nation's governors of significantly affecting the participation of women, minorities, people with disabilities, and, indeed, all students in science, mathematics, and engineering. ▲

Model for the Evolution of Intervention Programs



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Women, Minorities and Persons with Physical Disabilities in Science and Engineering: Contributing Factors and Study Methodology



Marsha Lakes Matyas

The continuing national need for personnel trained in the areas of science, engineering, and technology has been well documented (U.S. Congress 1985, 1989). Unfortunately, several sectors of the U.S. population remain underrepresented in training programs and professional positions in these fields. Women currently comprise 45% of the U.S. employed labor force but only 16% of all employed scientists and engineers (NSF 1990). Women employed in science and engineering are concentrated in psychology and the social and life sciences (49%) where unemployment rates are higher (2.5%, 2.4%, and 2.1%, respectively) than in the other sciences, while male scientists and engineers are concentrated primarily in engineering (59%) where unemployment rates are lower (1.2%) (NSF 1990).

Among certain minority groups, underrepresentation in science and engineering professions also continues to be a serious problem. While Blacks and Hispanics comprised 10% and 7%, respectively, of the U.S. employed labor force, they represented only 3% (each) of all employed scientists and engineers in 1988 (NSF 1990). Like women, Black scientists (44%) tend to work in the life and social sciences and psychology. Unlike women, however, a large proportion (62%) of Black scientists and engineers are employed in engineering. Minority scientists and engineers are more likely than are their White colleagues to be unemployed or underemployed, or to work in non-science and engineering jobs (NSF 1990). The status of American Indians in science and engineering is somewhat less clear than that of other minority groups due to the difficulties in collecting data on a small population and in obtaining accurate reports of American Indian heritage on survey instruments. (NSF 1990).

Persons with physical disabilities comprise between 2% and 16% of all scientists and engineers nationally, depending upon the particular definition of "disability" used (Task Force on Persons with Disabilities 1990). However, they suffer a higher unemployment rate than do other scientists and engineers (NSF 1990). Even so, the labor force participation rate for scientists and engineers

with physical disabilities (83%) is much better than Census Bureau estimates for the employment rate (26%) of the overall U.S. population with physical disabilities (U. S. Bureau of the Census 1983).

Access to science and engineering careers is especially important for people with physical disabilities because, traditionally, they have tended toward degree programs in fields with high unemployment rates such as bachelor's degrees in psychology or "general business." The lower unemployment rates in many science and engineering fields and the opportunities for co-op experience, especially in engineering, can change this trend.

Persons with physical disabilities also must deal with a powerful incentive to avoid paid employment entirely because it makes them ineligible for federal benefits which pay for physical aides and personal assistants. If they are employed in low salary positions, it may not be cost effective to remain employed. The higher earning potential afforded by science and engineering careers can allow more persons with physical disabilities to enter the active labor force. Therefore, although the problems are not identical, the flow of persons with physical disabilities, like that of women and minorities, into science and engineering fields, requires study and action.

The Educational Pipeline

In order to determine appropriate actions for increasing the number of women, minorities, and persons with physical disabilities in science careers, it is necessary to understand the educational pipeline which future scientists travel. According to Berryman (1983), the "scientific/mathematical talent pool" decreases at successive points along the pipeline. Prior to high school, the pool includes students who express career interests in quantitative fields. During high school, it includes those who have not only planned careers in quantitative fields, but who also enroll in elective mathematics and science courses. Although some migration into the scientific talent pool does occur during grades 9-12, "after high school migration is almost entirely out of, not into, the pool" (Berryman 1983). From this point on, the pool decreases in size. As students choose college majors, change majors during college, and choose professional or graduate areas of study, the proportion of students choosing science-related work consistently decreases.

Because of their underrepresentation in the sciences and engineering, the progress of women, minorities, and disabled persons in this educational pipeline is of particular concern. "All subgroups lose members as they progress through the system; the issue is whether, at particular points in the process, a subgroup loses fewer than all other groups" (Berryman 1983).

Minorities

The proportionately small number of minority students (excluding Asian American students) initially enrolling as science and engineering undergraduate majors is well documented (College Board 1985; NSF 1990). If one looks only at college-bound seniors, however, White, Black, Mexican American, Latin American, and Puerto Rican students are about equally likely to plan to enroll as science or engineering majors; American Indian students are somewhat less likely to do so (NSF 1990). However, Blacks and Hispanics

who select science majors tend to pursue the social sciences, an area where unemployment is high and wages are low, rather than the physical sciences where more jobs are available and salaries are higher (U.S. Congress 1989).

Minority and majority students also differ in their choice of institution. Black full-time students (34%) are more likely than are non-Black full-time students (26%) to enroll in two-year colleges, instead of in four-year colleges or universities where science and engineering departments are often better equipped and where both Black and White students are much more likely to complete their bachelor's degrees (College Board 1985). Over half of American Indian and Hispanic undergraduate students are enrolled in public 2-year institutions (Smith 1989).

The role of the predominantly Black colleges and universities should not be underestimated. A large proportion (34%) of Blacks who completed degrees in 1980-81 in agriculture, computer science, biology, mathematics, physical science, and social science attended predominantly Black colleges and universities (College Board 1985) and, according to the National Research Council, Black colleges and universities are the primary source of Black students who go on to pursue doctoral degrees (Thurgood and Weinman 1989).

For Hispanic students, regional differences appear; Puerto Rican and Mexican American students tend to live in different geographic areas of the country and, therefore, tend to receive degrees from institutions in those areas. The University of Puerto Rico is one of the primary baccalaureate origins of Hispanics. This institutional influence is also reflected in doctorates; Puerto Ricans receive proportionately more science doctorates compared to Mexican Americans.

Persistence rates for Black students in all majors and at both four-year and two-year institutions are lower than those for White students (National Center for Education Statistics in College Board 1985; U.S. Congress 1989). Black students earned only 6.4% of all bachelor's degrees from 1976-1981, but in 1980, they accounted for 10% of all undergraduate students (College Board 1985). The persistence rates for minority students enrolled in math- and science-based majors are even lower (Garrison 1987). National data suggest similar trends for Black, Hispanic, and American Indian students across the country (NSF 1990; Garrison 1987). In fact, the number of science and engineering bachelor degrees awarded to Blacks declined during the 1980s (NSF 1990).

Finally, minority students still earn extremely low proportions of science and engineering doctorates. As Table 1.1 indicates, American Indians earned less than 1% of doctorates in any science or engineering field in 1988, and Blacks and Hispanics earned less than 3% in any field. Notably, however, institution type played a large role in producing Black bachelor degree recipients who went on to earn doctorates; of the ten institutions with the highest productivity of Black baccalaureates who went on to earn doctoral degrees, all but one were Historically Black Colleges and Universities (HBCUs), and all but one were private institutions (Thurgood and Weinman 1989).

Women

It is also well documented that female students are less likely than are male students to choose undergraduate science and engineering majors (NSF 1990; U.S. Congress 1989). Nearly 39% of the male 1988 college-bound seniors compared to 26% of their female cohorts, planned to major in science or engineering. Furthermore, women who choose science and engineering tend to

select traditional majors; among female 1988 college-bound seniors, 55% intended to major in the social, behavioral, or life sciences, compared to 26.2% of males (Table 1.2). Men are most likely to major in engineering, an area much less likely for women to choose. Women remain, therefore, less likely to major initially in science or engineering, particularly in the physical sciences and engineering.

What is often less well-documented is the lower persistence rates in science and engineering majors among women who initially major in science or engineering. Although a number of studies have indicated that young women earn higher grades in college science and mathematics courses than do their male peers, they are less likely to maintain high occupational goals and are more likely to switch from science to non-science majors (LeBold 1987; Manis, Thomas, Sloat and Davis 1989; Matyas 1987). Therefore, in the educational pipeline, women are leaving the science and engineering undergraduate track even though their initial interests are in science or engineering and their grades are comparable to or better than those of their male cohorts (Matyas 1987).

Finally, women accounted for over a third of graduate students in 1988 and have steadily increased their share of earned doctorates over the past decade. In 1988, women earned a substantial proportion of life science doctorates (37%) but, despite increases, continued to earn limited numbers of degrees in the physical sciences (16%, N=880) and in engineering (7%, N=286). Similar to minority students, women and men earning doctorates differed in their baccalaureate origins. The top 30 institutions producing women B.A.'s who go on to earn doctorate degrees includes more private institutions than does the top 30 for men (Coyle and Syverson 1986). The list also includes three traditionally women's institutions. This finding agrees with that of the Women's College Coalition which suggests that the supportive and confidence-inspiring atmosphere typically found at women's colleges may be responsible for the fact that almost half of their graduates work in traditionally male-dominated careers (Women's College Coalition 1986). Institutional factors, therefore, may play a significant role in retaining women in science and engineering majors.

Persons with Physical Disabilities

In Fall 1986, students with physical or learning disabilities accounted for nearly 11% of undergraduate students and over 8% of graduate students (Task Force on Persons with Disabilities 1990). Nearly 40% of these students had a vision-impairment and 26% had a hearing-impairment. Less than 20% had an orthopedic disability. Nearly one-quarter of undergraduate students with disabilities chose to major in business, almost 11% selected natural sciences as their major field of study, and just over 9% were enrolled in engineering (Table 1.3). These proportions are very similar to those for students without disabilities.

It is difficult to acquire data on the persistence of students with physical disabilities in science and engineering majors; however, a study by Scherer indicated that attrition rates among hearing-impaired students are one-third higher than among hearing students (Jones and Watson 1990). Also, data from the 1988 Survey of Recent Science and Engineering Graduates indicate that students with disabilities received only about 1% of the total science/engineering bachelor's degrees in contrast to accounting for over 10% of enrolled

science/engineering undergraduate students, suggesting that significant attrition may occur among students with physical disabilities (Task Force on Persons with Disabilities 1990).

In the most recent National Science Foundation report on women and minorities in science and engineering, some minimal data were published on scientific and engineering professionals with physical disabilities. In 1988, it was estimated that 94,000 scientists and engineers had a physical disability, accounting for 2% of the science/engineering work force (1990). As expected, the percentage of scientists and engineers with physical disabilities increases with age, ranging from 0.5% among those under 30 to 6.5% among those age 60 and older. It is unclear, however, what proportion of scientists and engineers with physical disabilities already had a disability during the undergraduate years and what proportion became physically disabled at some point after their training. Obviously, there is a critical need for more quantitative information concerning the undergraduate experience of students with physical disabilities who are majoring in science and engineering and their experiences as members of the science/engineering work force.

Factors Affecting Recruitment and Retention

The process of choosing a science or engineering major in college and then persisting in it through receipt of a bachelor's, master's, or doctoral degree is complex and involves literally hundreds of factors for each individual. These range from factors as broad-based as the student's inherent abilities and learned skills to ones as specific as a discouraging or encouraging remark from a counselor or science teacher. Research indicates, however, that some factors are important for significant proportions of students. In 1985, the AAAS Office of Opportunities in Science convened a meeting of researchers and program implementors to ascertain the status of research on women and minorities in science and engineering, including the development of science interests and the choice of science and engineering careers. It was evident from the discussions that much more research has been done on females than on minorities concerning these issues (Malcom, George, and Matyas 1985). A subsequent conference on persons with physical disabilities in science revealed that little quantitative work has been done in this area (Linkages Project 1986); findings of that meeting will be described at the end of this section. For women and minorities, some similar factors seem to be influential and may be classified as academic factors, student attitudes and experiences, influence of significant others, and institutional variables.

Academics

Traditionally, many of the variables used by institutions to predict a student's potential success in a career or major are measures of *ability* in various forms: Scholastic Aptitude Test (SAT) and Graduate Record Exam (GRE) scores; grade point averages; class rank; and number and kind of courses completed during high school and college. Higher SAT and GRE test scores are related to choice of a quantitative major and entry into graduate school for both majority and minority students. For female students, the picture is less clear. Traditional variables predict enrollment in future science courses and attrition from science and engineering-related majors fairly well for males, but not for females (Matyas 1987; LeBold, Linden, Jagacinski, and Shell 1983).

In particular, the value of SAT-M scores in "predicting" performance in higher education for women and sex differences in science career choice has been questioned. DeBoer (1984) found SAT scores to be poor predictors of persistence in science careers among women and several studies indicate that they under-predict the level of women's performance in college courses.

High school preparation in science and mathematics has been termed the "critical filter" for both minorities (Beane 1985) and women (Sells 1978). The lower participation rates of women and minorities in advanced/elective high school science and mathematics courses remains a problem (NSF 1990). On the 1986 NAEP (National Assessment of Education Progress), minority students also displayed lower mathematics achievement, compared to majority students, although this achievement gap has narrowed since the 1976-77 assessment. Likewise, male students outperformed female students on the 1986 NAEP mathematics assessments (ETS 1988). In terms of high school grades, however, females receive similar or higher grades in high school than males (Peng, Fetters, and Kolstad 1981; LeBold 1987).

Student Attitudes and Experiences

According to the NAEP assessments, elementary age Black and Hispanic students, and female students of all racial/ethnic groups like mathematics and science, find them interesting, and hope to study more mathematics and science. Even by high school, many students retain their positive attitudes about mathematics and science (Kahle 1979). Unfortunately, according to Beane (1985), these positive attitudes "...are gradually overshadowed by a number of other factors as minority children progress through the intermediate and junior high school years. The common pattern of behavior becomes mathematics avoidance which closes the door to successful participation" (p. 8). While half of Black third graders and 55% of Hispanic third graders said science made them feel interested, only 27% and 28%, respectively, said science made them feel successful (Weiss 1990).

Female students lose their positive attitudes much earlier. Data from the three most recent NAEP assessments and from a large number of independent studies indicate that, from about ninth grade onward, males express more positive science/mathematics attitudes and greater interest in science courses and careers (Malcom, George, and Matyas 1985; ETS 1988). Typically, however, these interest differences are small (Steinkamp and Maehr 1984). Nevertheless, as for minority students, negative attitudes can encourage young women to avoid elective science and mathematics courses, therefore reducing their opportunities to choose science and engineering majors and careers.

Confidence in mathematics and science is also an important predictor of science and engineering major choice in college (Hackett and Betz 1984; DeBoer 1984; LeBold 1987). For women, although they are confident of their abilities in traditionally feminine areas (Hackett and Betz 1984), they tend to rate their science and mathematics abilities lower than do males (Kahle and Matyas 1987; LeBold 1987). Furthermore, success in science does not appear to increase feelings of competence among young women as it does among young men (DeBoer 1984). When faced with failures, females are less likely to return to the same task than are males (Mosley and Sullivan 1984). According to Duran (1987), studies are needed to determine whether the same processes occur among minorities in science and engineering.

The student's background of extracurricular science-related experiences also seems to be important in developing and maintaining interests in science, mathematics, and engineering. Science interest among high school students has been positively related to participation in science hobbies (Wright and Hounshell 1981). Unfortunately, female and minority students do not participate as often in extracurricular science activities as do their White male peers. Each of the three most recent NAEP studies indicated that, as early as age 9, girls' background in science-related extracurricular activities was much less extensive than that of boys, and that minority students of both sexes had participated in fewer science activities than had majority students (Kahle and Lakes 1983; Hueftle, Rakow, and Welch 1983; ETS 1988). These racial and gender differences in science activities precede later gender differences in science achievement and attitudes (Haertle, Walberg, Junker, and Pascarella 1981; Kahle and Lakes 1983; Beane 1985) and, at the undergraduate level, in persistence in science majors (Matyas 1987). In fact, for minority students, participation in a summer or co-op engineering job is one of the most significant factors in persistence in undergraduate engineering programs (NAS 1977).

Both majority and minority women who select science and engineering majors frequently must also deal with the perception that their career choice may conflict with or prevent future family responsibilities. "For men, the process of career selection is relatively independent of mate selection...A young woman, however, takes her potential mate into consideration when selecting career goals" (Hawley 1972). Hawley's statement may seem somewhat outdated, but a series of studies over the last twenty years present evidence that family/career conflict continues to be an important problem for young women choosing careers.

McLure and Piel (1978) surveyed college-bound women of high academic ability who chose not to pursue science/mathematics careers. When asked about barriers to choosing a science/mathematics career, they indicated that the potential for family/career conflicts was the most important barrier. "Apparently, the home-career conflict has such a strong influence on women's career patterns that even the anticipation of possible difficulties in reconciling future role demands shapes girls' career decisions" (p. 180). Matyas (1987) found that undergraduate women who persisted in science-related fields expected their future husbands to take responsibility for a larger proportion of household duties than did women who switched to non-science majors. Most recently, Manis et al.'s (1989) survey of undergraduate students at the University of Michigan found that women were more concerned than were men about the impact that family concerns could have on their career and choice of field: "...while men might recognize that maintaining a relationship could affect their decisions about where to locate, they were not apt to think in terms of the impact of parenthood on their career" (p. 17). Manis' findings also indicated that women majoring in science fields were more likely than other women to view family-career conflict as a serious problem for women. Therefore, although social expectations about women and work have evolved, women's concerns about combining career and family continue, especially when the career is in a traditionally "masculine" area.

Influence of Significant Others

Teachers, parents, and peers are important factors in students' development of science and mathematics interests, skills, and confidence. Parental education and socio-economic status are important mediators of minority

students' high school performance in mathematics and science, choice of a quantitative science major, postsecondary educational plans, and persistence in engineering majors (College Board 1985; Landis 1985; Garrison 1987). Berryman's (1983) study concluded that, "being second-generation college not only increases, but also equalizes, choice of quantitative majors across the White, Black, American Indian, Chicano, and Puerto Rican subgroups...[The] equalization occurs when parental education shifts from no college to any college". (P. 10)

For women, the picture is not so encouraging. Parental aspirations for and encouragement in science studies do not seem to be similar for sons and daughters. Parents tend to have less confidence in their daughters' mathematics abilities, beginning as early as first grade (Eccles and Jacobs 1986; Entwistle and Baker 1983). Also, male and female undergraduate science majors' beliefs about their parents' life goals for them differ. Female science majors, more often than males, felt that their parents wanted them to "be happy", while male science majors' perceptions of their parents' goals for them were more career oriented (Manis et al. 1989).

Likewise, both precollege and college teachers have different attitudes and expectations about male and female, majority and minority, students. Minority women scientists cited lower teacher expectations for minority students as one of the most important barriers to increased participation of minority students in science (Hall 1981). Expectations are often translated into action as *tracking* of students. Raze found that "even high-achieving African-American students tend to be placed in low-ability groups or tracks while low-achieving white, middle class students tend to be placed in higher tracks or ability groups" (Jones and Watson 1990, 36).

Similar results have been found for female students. Effects of differential teacher expectations may begin in the primary and secondary grades and continue through graduate school (Hall and Sandler 1982). A series of research studies have shown that during preschool, elementary school, junior high school, high school, and college, teachers interact more with males than with females and their interactions with males tend to encourage independence and academic excellence than their interactions with females (Kahle and Matyas 1987). These differences do not go unnoticed by female students. Lack of encouragement from teachers or counselors was cited as a serious problem by 19% of women science majors in one study (Manis et al. 1989).

The attitudes of friends also have been found to play a role in establishing students' science attitudes and interest. A 1983 study of exemplary precollege science, engineering, mathematics, and computer science intervention programs for female and minority students found that development of supportive peer relationships was a key factor in maintaining students' interests in science and mathematics (Malcom 1983). Peer support is especially important for female students since peers can affect the student's perception of the social acceptability of excelling in science and math. At the college level, the influence of male friends appears to be especially important to young women pursuing traditionally masculine careers (Lemkau 1983; Manis et al. 1989).

Finally, a lack of "role models" or "mentors" has often been cited as contributing to the dearth of women and minorities entering science and engineering professions. A lack of minority engineering faculty is one of the key factors in attrition of minorities in undergraduate engineering majors (NAS 1977; Garrison 1987), and role models are a critical element in exemplary precollege science/engineering intervention programs (Malcom 1983). Women choosing traditionally masculine majors in college are more likely to report

having had a role model than are women choosing traditionally feminine majors (Weishaar, Green, and Craighead 1981; LeBold et al. 1983; Manis et al. 1989; Kingdon and Sedlacek 1982). Furthermore, undergraduate women who have a role model, compared to those who do not, hold higher degree expectations, are more likely to enroll in graduate school, and display greater career commitment (Speizer 1981; Mokros, Erkut, and Spichiger 1981). The lack of female and minority science and engineering faculty on campus, therefore, can contribute to the attrition of female and minority students from undergraduate and graduate degree programs in science and engineering (Manis et al. 1989).

Institutional

Several institutional factors have been cited as instrumental in students' initial enrollment and retention in the sciences and engineering. Financial aid, the inflexibility of the science and engineering curriculum, and the overall campus climate all seem to play a role in the selection and retention process.

For many minority students, financial aid is a crucial factor in their decision to begin and complete a college degree. Of those attending four-year colleges, Black and White students receiving financial aid withdrew at similar rates (24% and 21%, respectively). However, among students at those colleges but not receiving financial aid, Black students (46%) were much more likely to withdraw than were White students (29%) (NCES in College Board 1985). The racial difference in the relationship of withdrawal rates to financial aid is even more dramatic at two-year colleges. Recent studies indicate that not only is financial aid related to persistence in higher education, but the amount and type of financial aid has additional impact for minority students (Murdock 1987; Stampen and Fenske 1988).

For women, the receipt of financial aid is related to both persistence and to intellectual self-esteem (Patterson and Sells in Hall and Sandler 1984). Among 1987 college-bound seniors planning to major in science or engineering fields, women, more than men, were concerned about finding funds for college (NSF 1990). Unfortunately, women do not receive the same amount or type of financial aid as men. Hall and Sandler (1984) suggest that undergraduate financial aid officers may assume "that men have greater need of educational credentials and therefore of [financial] aid...[or] less often encourage or nominat[e] women to apply for prestigious national scholarships, fellowships, awards, and prizes." At the graduate level, women (31%) are more likely than men (21%) to support their studies through personal sources of support. Women in science and engineering majors (42%) are less likely than men (52%) to have a university research assistantship (NSF 1990).

The structure of the science and engineering curriculum also has been cited as a source of retention problems, especially for minority and female students. Since these students are less likely to have taken a full course sequence of mathematics and science, the rigid mathematics and science course sequences typically found at the undergraduate level can force students who want to major in a science or engineering field to add on extra years of schooling. Considering the previous discussion of the importance of financial aid, this may not be a realistic alternative, and students may, therefore, be forced to choose other majors. Likewise, the rigid structure of the curriculum also creates difficulties for non-traditional students such as re-entry or part-time students.

Finally, the classroom and campus "climate" in which undergraduate students live and learn must be considered. Of the nineteen factors cited by the NAS Committee on Minorities in Engineering Retention Task Force as key in

retaining minority students in engineering, nine dealt either with student access to services, resources, and admission (financial aid, counseling, tutoring, and admission criteria) or with the general campus climate for minority students (existence of minority student organizations, faculty attitude and majority student attitude toward minority students, presence of minority faculty members, and the urban or rural setting of the school) (Landis 1985). According to Minor:

Minority students attending predominantly white institutions are to a great extent ethnically isolated in their academic environment and it is taken for granted that they will readily adjust. The majority groups of students as well as the faculty and the administration are not called upon to alter their attitudes or the institutional environment. The minority student is under great pressure to adjust or else. (Landis 1985)

In fact, as noted earlier, the absence of the "chilly" climate minority students often encounter in the classrooms and campuses of predominantly White universities may account for the success of the predominantly Black colleges and universities in producing a large proportion of Black graduates in certain areas of science.

Although they comprise over half of all undergraduate students, women students encounter a similar climate at both the undergraduate and graduate levels. Astin's (1977) longitudinal study of college life concluded that: "Even though men and women are presumably exposed to common liberal arts curriculum and other educational programs during the undergraduate years, it would seem that these programs serve more to preserve, rather than to reduce, stereotypic differences between men and women in behavior, personality, aspirations and achievement" (P. 216).

According to the American Council on Education, the situation did not changed dramatically in the following decade: "Women are still second-class citizens on our college campuses--unrepresented in the curriculum, often put down in the classroom, and under-represented in the major leadership roles in higher education" (Shavlik, Touchton, and Pearson 1987, 5).

The differential treatment of women in college classrooms, especially in traditionally masculine fields, has been well documented (Hall and Sandler 1982). Women often receive the message that their presence in science, mathematics, and engineering courses will be tolerated, but not welcomed. Differential treatment ranges from day-to-day "micro-inequities" which give subtle messages that women are not as competent in masculine fields (Hall and Sandler 1982) to blatant sexual harassment which devalues women's role as students (Dzeich and Weiner 1984). In sum, the undergraduate experience for women, especially those majoring in traditionally masculine areas such as science and engineering, is quite different from that of their male peers and does not tend to build their confidence in their skills and abilities.

Factors Affecting Students with Physical Disabilities

As noted earlier, little work has been done to delineate the barriers encountered by science and engineering students with physical disabilities. However, at a AAAS-sponsored conference on research in science, technology, and disability (Linkages Project 1986), several critical problems were identified.

First, students with physical disabilities often suffer from a lack of academic science and mathematics exposure in high school, especially laboratory experiences. Students are often discouraged from enrolling in laboratory courses because schools have few resources and little experience in adapting equipment for their use. A similar scenario occurs at the undergraduate and graduate levels. Although adapting laboratory equipment for students with physical disabilities often is a simple and inexpensive procedure, and detailed information is available on adaptations and solutions (Reese 1985; Redden, Davis, and Brown 1979; HEATH 1986), science and engineering departments often feel they do not have on hand the equipment and expertise required to allow full participation of students with physical disabilities in the laboratory. Students may have to *push* for equipment to be made available, and many may be too discouraged to try (Redden et al. 1979).

Visually impaired students encounter serious problems when trying to acquire recorded textbooks for their science, math, and engineering courses. Recording for the Blind, Inc. utilizes volunteers to read texts; however, those with expertise in science and engineering are in short supply and, with the rapid turnover of information in these fields, students who must depend upon recorded texts often find the current course text unavailable (see Chapter 4). Likewise, visually and hearing-impaired students have difficulty finding an interpreter each semester who can handle the technical content of science and engineering courses. Unfortunately, due to the sequential nature of the science and engineering curriculum, an entire year can be lost if a trained interpreter is not available for quarter or one semester.

Other barriers often encountered by students with physical disabilities in science and engineering majors include: low faculty expectations of the student's abilities; reluctance of faculty to ask the student about needed accommodations; faculty assumptions that teaching students with physical disabilities requires extra time and trouble; limited access to library materials; and limited access to buildings, safety equipment, laboratory equipment (including labeling of equipment for visually-impaired students), and field trips (Redden et al. 1979).

A Search for Solutions

In summary, minorities, women, and persons with physical disabilities often face barriers which the typical, able-bodied White male never encounters. In the difficult and highly competitive areas of science and engineering, it is not surprising that these barriers are reflected in the low initial enrollments and persistence rates in science and engineering among these three groups. However, the disparities in opportunities and participation in science and engineering between men and women, majority and minority persons, and those with and without physical disabilities is only part of the picture. For more than two decades, researchers and program administrators have probed how to reverse these trends. Their probes have taken the form of studies and intervention programs, many of which have been created and housed at U.S. higher education institutions. Many of these studies and programs have given us a good idea of what works. The current study explores these efforts more fully: How frequently are they implemented? What groups do they target (women, minorities, and/or persons with physical disabilities)? How are they funded? Methods for the study are described in the sections below. With support from the National Science Foundation, each of these questions was investigated and the answers comprise the remainder of this report.

Methods of Current Study

The study was conducted in four phases, each designed to gather specific types of information about institutional approaches to increasing the participation of women, minorities, and persons with physical disabilities in science and engineering. The four phases were:

1. Selection of the Study Sample—This phase included the development and implementation of criteria for the selection of higher education institutions for participation in the study.
2. Survey of Presidents and Chancellors—This phase gathered information about the institution as a whole, and how it approached the problems of recruitment, retention, and monitoring student progress.
3. Survey of Programs and Services—This phase utilized information provided by the presidents and chancellors to contact directors of specific programs and services at each institution that focus on increasing the participation of female and/or minority students and/or students with physical disabilities in science and engineering.
4. Case Studies of Selected Institutions—This phase provided the opportunity to take a closer look at how programs, services, and policies at institutions combine to create an atmosphere which encourages the participation and achievement of the target group students and faculty in science and engineering.

Each of these phases and the methodology used during each phase is described below.

Phase One: Selection of the Study Sample—Ideally, the study would have included information from all of the 2-year and 4-year higher education institutions in the U.S. However, limitations in funding and personnel prohibited this approach. Rather, a set of criteria was established to select a sample of institutions for study. The goal was to oversample institutions which were likely to have made specific efforts to encourage the participation of female and minority students and those with physical disabilities in science and engineering. First, the study was limited to 4-year+ institutions. In addition, the following criteria were used to select institutions for the study.

1. Institutions that attract or retain women in science and/or engineering, including institutions that:

- produced the greatest number or proportion of female B.A. recipients who went on to earn doctorate degrees in 1984;
- enrolled at least 400 undergraduate women majoring in engineering;
- had been cited in recent studies as having conducted studies or instituted policies, procedures, or programs to improve the "campus climate" for women; and/or
- had active student chapters of the Society of Women Engineers.

2. Institutions that attract or retain minorities in science and/or engineering, including institutions that: (a) produced the greatest number or proportion of Black, Hispanic or American Indian B.A. recipients who went on to earn doctorate degrees in 1984; (b) enrolled at least 150 (100, 10) undergraduate Black (Hispanic, American Indian) students majoring in engineering; (c) received support for at least five students from the National Action Council for Minorities in Engineering (NACME) Incentive Grants Program in 1985-86; (d) had active student chapters of the American Indian Science and Engineering Society or the Society for Hispanic Professional Engineers; (e) received grants from the National Science Foundation program, Research Improvement in Minority Institutions (RIMI); (f) had model precollege science/mathematics compensatory programs for minority students; and/or (g) had at least 20% Black, Hispanic, or American Indian students in the academic year 1984-85.

3. Institutions that attract or retain students with physical disabilities, including institutions at which at least 4% of the 1984-85 student body were students with physical disabilities.

4. Institutions that train large numbers of graduate and undergraduate students in science and engineering. Because of the important role they play in training graduate students in science and engineering and in preparing large numbers of undergraduate students for careers in science and engineering, institutions that received large amounts of federal research dollars also were included in the study. Specifically, the sample included: (a) the fifty degree-granting institutions that received the largest amount of total federal funding in fiscal year 1986; (b) all of the degree-granting institutions that received at least \$5,000,000 in National Science Foundation funds in at least one of the years 1981-1985; and (c) the fifty degree-granting institutions that received the largest amount of National Science Foundation funding in at least one of the years 1981-1985.

The initial list of institutions provided by application of these criteria was reviewed by the AAAS staff; the AAAS Committee on Opportunities in Science; the Subcommittee on Higher Education of the Federal Task Force on Women, Minorities, and the Handicapped in Science and Engineering; and the AAAS-Linkages Project Advisory Board. Suggestions for additions to the list were made by each group. Finally, the list was reviewed to determine whether a minimum level of representation for each state had been attained. Of the total 4-year institutions in each state, at least 8%, or 3 institutions, were included, whichever was larger. Where it was necessary to add institutions to the list, those with the largest number of students and the highest degree levels offered were selected.

The final sample for the study included 503 U.S. colleges and universities, representing a wide variety of institutional types and geographic locations. However, the sampling procedure was not designed to create a nationally representative sample. Rather, this sample included institutions where efforts to increase the participation of women, minorities, and persons with physical disabilities in science and engineering were likely to be found. Consequently, minority institutions such as Historically Black Colleges and Universities (HBCUs) and women's colleges were oversampled.

Phase Two: Survey of Presidents and Chancellors—Although national data and data from isolated institutions suggested that the recruitment and retention of female, minority, and physically disabled students in science and engineering majors is an extensive and persistent problem, systematic information had not been collected on the retention rates of these target students, the types of

programs/services offered, or the institutional characteristics which may be related to the recruitment and retention of these groups. Although often speculated, it was not known whether, for example, the size or type of the institution or the ratio of men to women or of majority to minority students in the student body were related to the recruitment or retention of women, minorities, or physically disabled persons in science and engineering majors.

The survey of presidents and chancellors, entitled, "Human Resources in Science and Engineering: A Survey of Selected Institutions of Higher Education" was developed by project staff and reviewed by members of the AAAS Committee on Opportunities in Science. The primary purpose of the survey was to obtain the names of contact persons at the institutions who direct programs and services for women, minorities, and/or persons with physical disabilities in science or engineering. In addition, the survey was designed to obtain enrollment, attrition and graduation rate information on target group students in science and engineering majors or to determine the lack of availability of this information; information on the presence and status of faculty who can serve as role models for female and minority students and those with physical disabilities; general descriptive information on each institution; and specific information related to "campus climate" issues. Definitions were established for terminology used in the surveys in both Phase I and Phase II of the project (Figure 1).

The survey was sent to presidents and chancellors of the sample institutions under cover letters from both the project staff and the Director of the National Science Foundation. Presidents and chancellors were selected as the initial institutional contact point for the study rather than recruitment/retention program directors because presidents and chancellors have the greatest access to available data and, if necessary, could request data which might not be easily accessed by program directors; and presidents and chancellors could appropriate staff time required to gather information requested by the survey. Response rates and results from this survey are discussed in Chapter 2.

Phase Three: Survey of Programs and Services—Science/engineering programs or services which target female and minority students and those with physical disabilities have never been evaluated, as a whole, to determine: to what extent they are effective; which components of the programs/services work best; and which program/service models could be disseminated to other institutions. In fact, in the program descriptions offered by Bogart (1984), program administrators seldom offered quantitative evaluations of their programs.

In completing the survey of presidents and chancellors, each institution provided a list of contact persons for programs and services on campus which are targeted at increasing the participation of women, minorities, and persons with physical disabilities in science and engineering. These programs could be targeted at precollege, undergraduate, or graduate students; postdoctoral fellows, or faculty members. Each of the designated contact persons received a follow-up survey designed to learn about the program's goals and history, participants, place within the institutional structure, and evaluated impact.

Figure 1.1

I. Science and Engineering Fields

Physical sciences—chemistry, physics, astronomy, and other physical sciences, including metallurgy

Mathematical sciences—mathematics and statistics

Environmental sciences—earth, atmospheric, and oceanographic sciences, including geophysics, seismology, and meteorology

Life sciences—biological, agricultural, and medical sciences (excluding those primarily engaged in patient care)

Computer specialties

Engineering

The following fields were not included in the study as science and engineering fields:

Social sciences—economics (including agricultural economics), sociology, anthropology, and all other social sciences

Psychology

II. Physically Disabled

Students or faculty who have physical disabilities: blindness or visual impairment, hearing and/or speech impairment, mobility impairment, or chronic health problems. The study did not include students or faculty with only learning disabilities.

III. Minority

For the purpose of this study and this report, "minority" refers to persons from racial/ethnic groups which, traditionally, have been underrepresented in science and engineering studies and fields compared to their representation in the U.S. population. Specifically, these include Blacks, Hispanics (see definition below), and American Indians.

IV. Students

"Students" refers to full time undergraduate students who are U.S. citizens.

Graduate students refers to full or part-time students who are U.S. citizens.

V. Faculty

"Faculty" refers to full and part-time faculty members who are U.S. citizens.

VI. Hispanic

"Hispanic" includes Mexican Americans, Puerto Ricans, Cubans and other Hispanics who are U.S. citizens.

Since programs that specifically target science/engineering students with physical disabilities are extremely rare, two separate surveys were developed for this phase of the study:

1. "Human Resources in Science and Engineering: Survey IIa—Programs for Women and Minorities at Selected Institutions of Higher Education" was designed to gather information about programs that specifically target women and/or minorities.
2. "Human Resources in Science and Engineering: Survey IIb—Programs and Services for Physically Disabled Students at Selected Institutions of Higher Education" was designed for completion by Disabled Student Services Offices (DSSs), where students in any major field of study who have specific needs typically go for assistance.

Both surveys were developed by project staff and reviewed by members of the AAAS Committee on Opportunities in Science, selected women/minority program directors, and selected directors of DSSs. After revisions, the surveys were distributed to the contact persons provided by the presidents and chancellors of participating institutions. Due to the large number of surveys distributed, no specific follow-up measures were taken. Results for Surveys IIa and IIb are discussed in Chapters 3 and 4, respectively.

Phase Four: Intensive Case Studies of Selected Institutions—The three surveys described above provided important quantitative and qualitative information on recruitment and retention of the three target groups in science and engineering. However, as discussed previously, many factors affect recruitment and retention, and not all of these are easily assessed by survey methods. Many factors, both positive and negative, are quite subtle, and may contribute either to a general "chilly campus climate" (Hall and Sandler 1984) for members of these target groups or to a positive and encouraging atmosphere. In order to strengthen the study, an objective and intensive examination of the individual components of exemplary model programs and institutions was warranted. Furthermore, insight into how these programs fit into and are influenced by the general institutional "climate" was necessary since, in many cases, it appears that programs and supportive administrative policies and personnel interact synergistically, creating an institutional atmosphere which promotes achievement and persistence among students in the target groups.

In Phase Three of the project, the "program" or "service" was the unit of study; in Phase Four, however, the "institution" was used as the unit of study. Twelve model institutions were chosen for intensive case studies. The institutions represented major research universities, women's colleges, and minority institutions. In order to be chosen for case study, the model institution had to house outstanding programs for at least two of the three target groups and the overall sample of institutions was selected to include a variety of program models and geographic locations. Additional details on selection of institutions is provided in Appendix B.

The case studies examined specific programs: how they operate, how they are funded, and how student participants view the program. Case study researchers also examined how the general campus climate for students in the target groups affects the success of the program or service. Finally, the case study researchers discussed with program directors and institutional administrators how the program fit into the overall undergraduate or graduate program and how "special" efforts can be "mainstreamed" into college and university programs. A summary of the case studies is presented in Chapter 5.

Summary

The task of increasing the participation of women, minorities, and persons with physical disabilities in science and engineering is a complicated one. This is not surprising considering the intricate web of factors which lead to their initial underrepresentation. However, research studies and intervention programs have clearly shown that the trend is not irreversible—that the factors can be changed. In a 1984 study of effective precollege programs focused on increasing the participation of female and minority students in science and engineering, Malcom found that the strategies that led to success in these programs were the same strategies that led to overall excellence in science and mathematics teaching in both in- and out-of-school settings. The research presented here indicates that the factors that seem to foster persistence and

achievement in science and engineering in higher education among these three target groups of students are characteristics of excellence in higher education. Among these are:

- a campus climate that fosters respect for diversity and achievement among all students, including positive attitudes and behaviors by all faculty and staff;
- access to educational opportunity via financial aid and, for students with physical disabilities, appropriate services and physical modifications;
- recognition of the diverse educational backgrounds of entering students and flexibility within the science/engineering curriculum and appropriate programs and services to accommodate this diversity; and
- high expectations of all students' potential and worth among faculty and staff to foster confidence among students.

Rather than focusing on what cannot be accomplished at higher education institutions, this study focuses on what can and is being accomplished at individual institutions and, often, by individual faculty and staff members. The specific strategies, policies, and programs which foster the characteristics of excellence described above can be disseminated. It is hoped that this study will provide additional ideas on how to begin. ▲

Table 1.1 Science and Engineering Doctorates Earned by U.S. Citizens by Racial/Ethnic Group and Selected Fields, 1989

Field	Percentage (number) of Doctorate Degrees				
	American Indian	Asian	Black	Hispanic	White
Engineering	0.2% (7)	3.8% (172)	0.5% (23)	0.6% (27)	34.7% (1,574)
Life Sciences	0.2% (12)	2.2% (138)	1.2% (75)	1.6% (58)	64.9% (4,116)
Physical Sciences ¹	0.4% (29)	2.1% (170)	0.7% (58)	1.4% (116)	55.7% (4,550)
Total	0.3% (93)	1.8% (624)	2.4% (811)	1.7% (570)	60.3% (20,688)

Note: Data from Thurgood and Weinman, 1989. Percentages do not total 100% since degrees earned by non-U.S. citizens were counted but not tabled here.

¹Includes physics, chemistry, and earth, atmospheric, and marine sciences.

Table 1.2 Intended Field of Study Among 1988 College-Bound Seniors Planning to Major in Science or Engineering, by Gender

Field of Study	Percentage of Students	
	Female	Male
Agriculture	3.8%	4.4%
Biological Science	13.7%	8.9%
Computer Science	8.8%	11.1%
Engineering	13.0%	45.9%
Mathematics	2.3%	1.8%
Physical Science	3.4%	5.4%
Social Science	55.0%	22.4%

Note: Data from NSF, 1990.

Table 1.3 Undergraduate Students by Major Field of Study and Disability Status, Fall 1986

Field of Study	Percentage of Students	
	Students with disabilities	Students without disabilities
Arts/Humanities	7.4%	6.4%
Business	24.4%	28.1%
Education	9.3%	8.6%
Engineering	9.8%	9.5%
Health	7.8%	9.7%
General Studies	7.3%	6.9%
Natural Sciences ¹	10.7%	10.7%
Social Sciences	8.6%	7.3%
Trade/Industrial	3.2%	2.5%
All others	11.4%	10.4%

Note: Data from Task Force on Persons with Disabilities, 1990.

¹Includes life sciences, physical sciences, mathematics, and computer sciences.

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Fostering Diversity at Higher Education Institutions



Marsha Lakes Matyas

An extensive literature now suggests, however, that the issues facing nontraditional students go beyond their individual or group backgrounds—and even beyond the particular interaction of their background with the institutional environment—directly to the question of whether institutions are designed to deal with diversity. The theme of alienation pervades the literature. It is a powerful voice in the literature concerning racial and ethnic minorities. It is also present in the literature focusing on women, the disabled, and other non-traditional groups. A synthesis of this literature suggests that our research, programs, and institutional and public policy must be focused not only on the “needs” of each nontraditional group but also on the organizational issues institutions must address (Smith 1989, 1)

Introduction

As described in Chapter 1, the initial phase of this study was a survey of the presidents and chancellors of a sample of 503 higher education institutions. The primary purpose of this survey was to obtain the names of contact persons at colleges and universities for programs and services that serve women, minorities, and physically disabled students. Specifically, the survey requested information on contact persons for programs and services currently in operation at the institution that were targeted at: (a) recruiting undergraduate and graduate students who are female, minority, and/or physically disabled into science or engineering majors; (b) retaining undergraduate and graduate students who are female, minority, and/or physically disabled in science or engineering majors; (c) recruiting and retaining faculty members who are female, minority, and/or physically disabled in science and engineering departments; and (d) providing support services to undergraduate or graduate students with physical disabilities in all fields of study.

The contact persons provided by the presidents and chancellors were sent follow-up surveys to gather information describing their specific programs and services. The information from that phase of the study is discussed in Chapter 3.

In addition to providing information on contact persons for programs and services, the survey also was designed to explore the responding institutions' level of commitment to increasing the participation and performance of women, minorities, and persons with physical disabilities in science and engineering. As stated by Jones and Watson (1990):

Developing strategies to reduce risk and increase the likelihood of retention and attaining a degree requires commitment by the institution. Institutional commitment can be evaluated using several criteria: admissions and recruitment, financial aid, counseling, support services and placement, curriculum, and environment. (P. 69)

This survey attempted to gather information on some of these criteria by asking responding institutions to provide:

- enrollment, attrition, and graduation rate information on specific groups of students in science and engineering when possible, and to determine how frequently those data were available;
- information on the presence of faculty who could serve as role models for target group students and the status of those role model faculty members;
- information related to "campus climate" issues concerning women, minorities, and physically disabled students; and
- general descriptive information about the institution.

The data gathered from these questions are discussed in this chapter and recommendations for future action are made.

Description of Sample

The selection process for the initial survey sample was described in Chapter 1. Response rates were analyzed by geographic regions and by institutional type (Figure 2.1). Response rates ranged from 37% at Liberal Arts colleges to 72% among Research Universities. The overall response rate was 55% (Table 2.1). Discussions with institutional contacts suggest that this may reflect the lack of computerized student records at smaller institutions that made it difficult to obtain the data necessary to respond to some of the survey questions. Response rates were generally consistent among the geographic regions, ranging from 49.7% in the South to 61.2% in the Midwest (Figure 2.2). In addition, the survey was successful in including a number of women's colleges and minority institutions in the study. Five women's colleges (four Liberal Arts colleges and one Professional/Other institution); 15 institutions serving primarily Black students (one Research University, ten Comprehensive Colleges and Universities, and four Liberal Arts colleges); and 17 institutions serving primarily Hispanic students (ten Comprehensive Colleges and Universities, two Liberal Arts colleges, and five Professional/Other institutions) responded to the survey.

Figure 2.1 Characteristics of Carnegie Institutional Classifications Research Universities (I and II)

- offer a full range of baccalaureate programs;
- are committed to graduate education through the doctorate degree and award at least 50 Ph.D. degrees each year; and
- give high priority to research, and receive at least \$12.5 million in federal support for research and development each year.

Doctorate-Granting Institutions (I and II)

- offer a full range of baccalaureate programs; and
- are committed to graduate education through the doctorate degree and award at least 20 Ph.D. degrees in at least one discipline and at least 10 Ph.D. degrees in at least 3 other disciplines.

Comprehensive Colleges and Universities (I and II)

- award at least half of baccalaureate degrees in two or more occupational or professional disciplines;
- typically offer graduate education through the master's degree; and
- enroll at least 1,000 full-time students.

Liberal Arts Colleges (I and II)

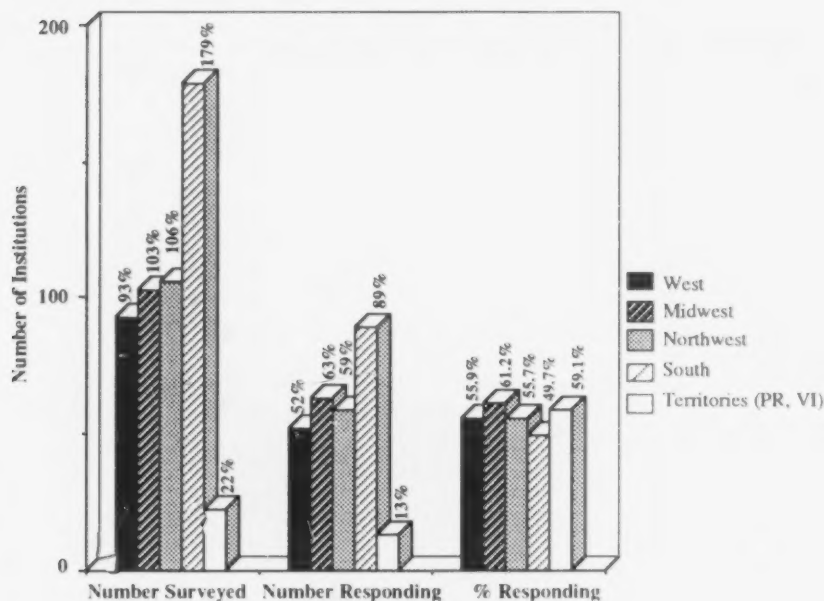
- are primarily undergraduate education institutions; and
- award either more than half of their baccalaureate degrees in arts and science fields (Type I) or in liberal arts fields (Type II).

Professional Schools and Other Specialized Institutions

- offer degrees ranging from bachelor's to doctorate;
- award at least half of degrees in a single specialized field; and
- for the purposes of this survey, include degrees in some field of science, mathematics, or engineering. For example, schools of theology, law, art, music and design were not included.

Note: Adapted from *Chronicle of Higher Education*, July 8, 1987, p. 22.

Figure 2.2 Response Rates for "Survey of Presidents and Chancellors" by Geographic Regions



Note: West, Midwest, Northwest and South regions are those designated by the U.S. Census Bureau.

Campus Climate Issues

The term "campus climate" has been used frequently in discussions of female and minority retention, especially for students in science or engineering majors. Shavlik, Touchton, and Pearson (1987) describe campus climate related to women as:

...those aspects of the institutional atmosphere and environment which foster or impede women's personal, academic, and professional development. Campus climate issues include a wide range of individual behaviors and attitudes as well as institution-wide policies and practices, formal and informal, which reflect differential treatment of [students]...With respect to students, climate issues include classroom and out-of-classroom experiences that affect the learning process. Regarding faculty and administrators, climate issues center on their professional experiences, characterized by subtle social and professional barriers which communicate to women that they are not quite first-class citizens in the academic community. (P. 7)

Tuition rates and financial aid

A number of individual studies have examined the impact that financial aid has on student persistence in higher education. Certainly, student attrition/persistence is affected by a wide variety of factors related both to the student and to the particular institution. Murdock's (1987) meta-analysis of over 60 research studies showed that financial aid is consistently an important factor in student persistence.

Does student financial aid have special impact for female or minority students or those with physical disabilities? Certainly, students with physical disabilities who require the services of interpreters, aides, or specific technologies benefit from support services provided by higher education institutions and state vocational rehabilitation agencies. For women, the receipt of financial aid is related both to persistence and to intellectual self-esteem (Patterson and Sells in Hall and Sandler 1984). In 1988, Stampen and Fenske reviewed the impact of financial aid on the participation of ethnic minorities in higher education with special attention to the plummeting minority enrollments in the late 1970s and the 1980s. They found that a number of factors, related to financial aid, inhibited the participation of Blacks, Hispanics, and American Indians in higher education in the 1980s:

- (1) the sharply accelerating rise in college costs, especially in tuition;
- (2) continuing inflation which, although lower than in the 1970s, combined with a level of funding to rob student aid of about one-fifth of its real purchasing power;
- (3) the shift in aid dollars from grants to loans, a type of aid shunned by many minority students; and
- (4) a renewed emphasis on high academic quality expressed in increased admission standards which included requirements for more high school mathematics courses than had been previously required. Many minority students, victims of a substandard and discriminatory school system, could not hope to meet such requirements. (P. 349)

In addition, they found that minorities often have college work-study jobs in which earnings are set according to needs-analysis-based estimates of the money required to meet expenses, while White students more often work outside the student aid system, resulting in greater earnings.

All of these factors combine to make financial aid and tuition costs an important consideration, especially for target group students. The current study asked about tuition rates and proportions of students receiving financial aid in all majors and in science/engineering majors. Average tuition rates ranged from a high of \$7,397 at Liberal Arts colleges to a low of \$2,015 at Professional/Other institutions. Liberal Arts colleges were also very likely to offer financial aid to students; 68% of all students at Liberal arts colleges received some type of financial aid. Professional/Other schools were also very likely to offer financial aid to students (72%).

Science and engineering students at the responding institutions were about as likely to receive financial aid as were students in other fields of study. However, it should be noted that only 60% of the responding institutions were able to provide this information. These findings are in contrast to previous studies which found that science and engineering students were more likely to receive financial aid of all sorts than other students, even accounting for high grades which qualify students for merit awards (U.S. Congress 1989). The current findings may reflect the over-sampling of HBCUs where considerable financial aid is based upon need.

Flexibility in declaration of majors

The undergraduate years are frequently a time of career exploration and decision. Unfortunately, in science and engineering, there is an informal barrier to career exploration since the undergraduate curriculum is often fairly rigid and sequential, making it difficult to switch into these fields after one or two semesters of study in a non-science field. This is a difficult factor to assess since each institution and, typically, each major field of study within the institution, has its own set of courses and requirements. As a very rough first estimate of the flexibility students have in career exploration at the institution, the survey asked at what point the student must declare a major field of study.

Less than 10% of the responding institutions required students to declare their major field of study at the time of application or admission, with the exception of Professional/Other schools (44%) which often offer a limited number of special degrees. About half of the institutions responding require students to declare their major field of study after earning 60 credit hours or, typically, by the end of their sophomore year. The other half of the institutions had varied requirements for declaring a major field of study, including a few schools that did not require students to declare their major until graduation. Therefore, students generally do not have to select science or engineering as a major field of study before entering the institution. However, this rough assessment does not account for the curricular and administrative barriers students may encounter if they want to switch from non-science/engineering to a science or engineering field after they begin their studies.

Climate Issues for Women and Minorities

According to Clewell and Ficklen's (1986) review of literature,

...students who are well integrated into the academic and social environment of the institution are more likely to persist to graduation. This finding is particularly important for minority students on majority campuses where they are less likely to fit in and more likely to feel alienated...A positive racial environment on a campus is associated with good academic performance and persistence...Feelings of alienation and not belonging on campus contribute to minority attrition. (P. 4-5)

In addition, Clewell and Ficklen concluded that characteristics of institutions which have good retention of minority students include a high level of institutional commitment, a stated policy on minority enrollments, and strong faculty support.

The current survey asked about general campus climate issues for women and minorities. Nearly 90% of the institutions responding to the survey provided information about an institutional sexual harassment policy (Table 2.2). Some also had conducted studies of campus climate issues for women and/or minorities. Research Universities and Doctorate-Granting Institutions were most likely to have done these. Less than a third of Liberal Arts Colleges and Professional/Other Institutions reported having conducted similar types of institutional studies.

Most science/engineering undergraduate students who attend a large institution will encounter a teaching assistant (or TA) during some course. Frequently, the graduate students who act as TAs are from foreign countries.

According to a survey by Bailey, the "typical foreign teaching assistant is a male pursuing a doctoral degree in math, engineering, or the sciences" (Bailey, 1984). Bailey's survey further found that, according to the foreign TAs, cultural differences between TAs and students were the number one problem encountered in teaching American students. Foreign students coming from countries where women and certain minority groups do not traditionally participate in higher education, particularly in areas such as science and engineering, may consciously or unconsciously discriminate against these students. If this is the case then, at minimum, foreign students who will work as graduate teaching assistants need to have training to be familiarized with accepted attitudes and behaviors in U.S. institutions concerning women and minorities. In fact, in Turitz's (1984) survey of foreign teaching assistant training programs at 15 higher education institutions, only two did not specifically include a component addressing cultural differences.

Research Universities and Doctorate-Granting Institutions are most likely to have foreign students working as graduate teaching assistants. Nearly 80% of the Research Universities responding had some sort of training program for foreign students who will be working as graduate teaching assistants. However, only about 50% of the Doctorate-Granting Institutions responding had similar programs. The current survey did not assess the curricular content of these training programs, and therefore it is not known whether they address issues of sex and racial/ethnic group discrimination.

Climate for Students with Physical Disabilities

According to the National Science Foundation's Task Force on Persons with Disabilities (1990), "negative attitudes are the single most significant barrier faced by students with disabilities at all levels of education and by others beyond their education in careers in science, engineering, and science education" (P. viii). In creating a positive atmosphere for students with physical disabilities, institutional personnel must consider access beyond the physical facilities of the institution, to both the academic and social life of the institution.

The survey assessed whether institutions had conducted studies of campus accessibility for students and faculty with physical disabilities. Research Universities, Doctorate-Granting Institutions and Comprehensive Colleges and Universities were most likely to have completed a study of campus accessibility to students with physical disabilities.

In order to provide services to students with physical and learning disabilities, many colleges and universities had established a disabled student services office (DSS). The current survey asked whether the institution had a DSS. The large majority of Research Universities, Doctorate-Granting Institutions, and Comprehensive Colleges and Universities had a specific office to serve the needs of students with physical disabilities (Table 2.2). Liberal Arts Colleges and Professional/Other Institutions were less likely to have a specific disabled student services office (DSS), but may have distributed the function of a DSS among a number of campus offices and departments.

Diversity Among Faculty Members

Minority and female faculty members play an important and specific role in recruiting and retaining female and minority students in science and engineering. Similarly, students with physical disabilities need to interact with scientists and engineers with disabilities. Blackwell (1988) points out several important roles for faculty members who are members of underrepresented groups in encouraging similar students: (1) demonstrating competence in subject matter, including excellent teaching, knowledge of subject matter, and sincere interest in students as individuals; (2) mentoring, that is, "using one's own experiences and expertise to help guide the development of others" (P.429); and (3) "intrusive advising," through frequent student contact to check on student academic progress and provide academic support, as needed. These types of activities can strongly influence female and minority students and those with physical disabilities to persist in science or engineering.

However, faculty members must be at the institution and in secure and productive positions in order to play these roles. Since the institutions in the current study were selected because of some demonstrated equity efforts, it was predicted that they would, collectively, have a significant resource pool of target group faculty members.

Responding institutions were asked to provide information on faculty by sex, racial/ethnic group, and physical disability in the following categories: (1) total full-time faculty; (2) full-time, tenured science/engineering faculty; (3) full-time, tenure-track science/engineering faculty; (4) full-time, non-tenure-track science/engineering faculty; and (5) part-time science/engineering faculty.

The availability of this information varied widely depending upon the specific target group, the faculty position and the type of institution (Table 2.3). In general, most institutions could provide information by sex and by racial/ethnic group in full-time tenured or tenure-track positions. Information on women and racial/ethnic groups was somewhat less available for non-tenure-track and part-time positions. When responding to questions on faculty members with physical disabilities, only one-third to one-half of responding institutions could provide this information.

Women. Overall, the highest percentages of women in science/engineering were found among the full-time non-tenure track faculty positions and part-time faculty positions (Table 2.4). Among all full-time faculty members, Liberal Arts Colleges had significantly higher representation of women, compared to all other institutional types ($p < .01$); Research Universities had the smallest percentage of female full-time faculty. Similarly, women were most highly represented among full-time, tenured faculty in science/engineering at Liberal Arts Colleges, Professional/Other Institutions, and Comprehensive Colleges and Universities; percentages of women in this category at Research Universities and Doctorate-Granting Institutions were significantly lower ($p < .01$). Liberal Arts Colleges also had significantly higher proportions of women in full-time tenure track science/engineering positions (compared to Research Universities, $p < .05$) and in full-time, non-tenure track science/engineering positions (compared to Professional/Other Institutions, $p < .05$). This may partly reflect the information provided by the five women's colleges.

In general, women are still found in the highest proportions in the non-tenure track positions in science and engineering. This is particularly

detrimental because persons in these positions are less likely to be allowed to apply for independent grants, set up an independent program of research, or establish a long-term commitment to a teaching program at the institution.

Racial/ethnic groups. Not surprisingly, most faculty members at most institutions participating in this study were White. This was especially true of the Research Universities and Doctorate-Granting Institutions and least true at the Professional/Other Institutions and Comprehensive Colleges and Universities which include many of the Historically Black Colleges and Universities (HBCU's).

Asian Americans were most likely to be found in the highest proportions as full-time faculty members at Research Universities. Within the fields of science/engineering, however, there were no significant differences in the average proportion of Asian American faculty members among the different institutional types. Among the various science/engineering faculty types, Asian Americans were most likely to be found in full-time, tenure-track positions and least likely to be found in part-time positions.

The overall percentage of Black faculty in this study was 9.3%. In science/engineering, Blacks were most highly represented in the full-time, tenure track faculty positions. However, these figures were highly influenced by the Historically Black Colleges and Universities and by other institutions at which at least 75% of the student population was Black. When the responses for these institutions were eliminated from the analysis, a different picture emerged: on average, only 2.5% of total full-time faculty were Black and, like women, the highest proportions of Black science/engineering faculty members were found in the non-tenure-track positions (Table 2.5). These figures are similar to those found nationally where, in 1987, Blacks comprised only 2% of all science and engineering faculty, 1% of all full professors in science and engineering, and 2% of both associate professors and assistant professors in science and engineering (NSF 1990).

A similar analysis was done for Hispanic faculty members. Although the percentage of science/engineering Hispanic faculty members ranged from 4.1% to 7.2% for the total sample, these percentages largely reflected the data from the ten Puerto Rican colleges and universities participating in the study. By selecting only data from non-Puerto Rican institutions, the results change significantly (Table 2.6). Few Hispanic faculty members were found in any type of science/engineering faculty position at any of the institutional types, both in the current survey and nationally, where between 1% and 2% of faculty are Hispanic, depending upon position level (NSF 1990).

While the proportions of Hispanic faculty members in responding institutions were low, the proportion of American Indian faculty members was almost negligible (Table 2.7). This finding was consistent among all institutional types and all science/engineering faculty types. There is a consistent and nearly complete absence of American Indian faculty members in science and engineering at U. S. higher education institutions.

As stated earlier, information concerning faculty members with physical disabilities was not generally available from the responding institutions; Table 2.8 presents the information that was available. Similar to the situation for American Indian faculty members, the percentage of faculty members who are physically disabled was very low, typically around 1%. The highest percentages were among part-time science and engineering faculty members and full-time science/engineering tenured faculty members. This may reflect physical disabilities which occurred during mid- or late-career.

Monitoring Student Progress

For all institutions, retention and its converse, attrition, are important concerns:

...[A]ttrition affects patterns of funding, planning for facilities, and the long-term academic curricula of institutions of higher education. Attrition affects the future labor market, because students are unprepared for the required roles and responsibilities (Jones and Watson 1990, iii).

For female and minority students in science and engineering, attrition rates are disproportionately high (U. S. Congress 1989; LeBold 1987).

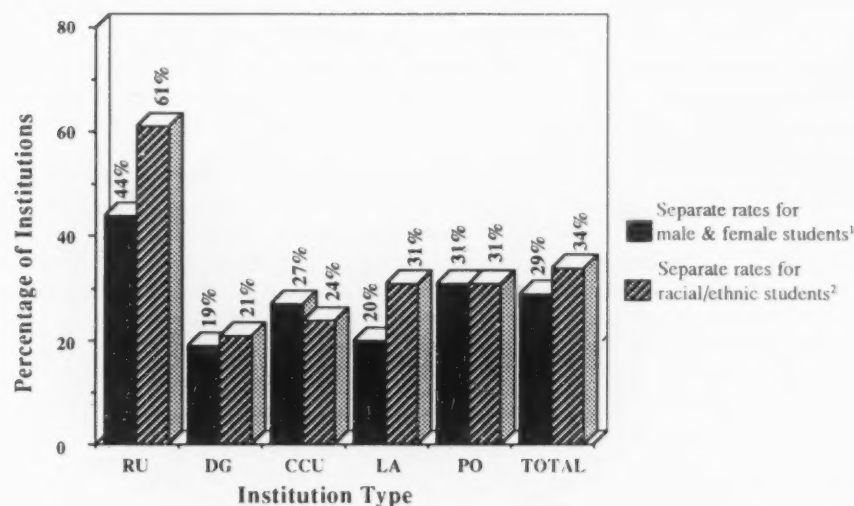
Because of the lack of regular data collection on students with physical disabilities, their retention rates in science and engineering are largely unknown. Isolated studies indicate that attrition is as much as one-third higher for students with hearing impairments (Scherer in Jones and Watson 1990). The retention rates for students with physical disabilities are undoubtedly lower than those of students without disabilities since, according to the National Science Foundation, "persons with disabilities are subject to double jeopardy—they face negative attitudes not unlike those faced by minorities and women plus barriers of accessibility, of communication, and, for some, of dealing with extended time required to do things, from obtaining a Ph.D. to accomplishing the tasks of everyday living" (Task Force on Persons with Disabilities 1990, viii).

In their 1986 study of effective institutional practices, Clewell and Ficklen found that systematic collection of data, monitoring, and follow-up are characteristics of institutions with successful retention of minority students. Therefore, the current study examined how student progress is monitored, particularly for these target groups. The survey asked whether the institutions routinely calculated graduation and attrition rates for undergraduate and graduate students and, if so, what method they used to calculate these rates. Results are presented in Table 2.9.

Colleges and universities responding to the survey were far more likely to routinely calculate graduation and attrition rates for undergraduate students than for graduate students. Research Universities were significantly more likely than were Comprehensive Colleges and Universities to calculate graduation and attrition rates for undergraduate students.

When asked whether they routinely calculated graduation and attrition rates separately for male and female students; for students of different racial/ethnic groups; and for students with physical disabilities, differences occurred among the target groups and among the institutional types. First, institutions were somewhat more likely to calculate separate graduation and attrition rates for racial/ethnic groups than for male and female students, especially at Research Universities (Figure 2.3). Institutions may be more aware of problems in retention of minority students and less aware of problems in retention of women. In addition, Research Universities were most likely to calculate both graduation and attrition rates by sex and by racial/ethnic groups among all the institutional types. Very few institutions calculated graduation rates for students with physical disabilities results were similar for attrition rates.

Figure 2.3 Routine Calculation of Graduation Rates by Student Target Group and Institution Type



¹ $X^2 = 11.03$, $df = 4$, $p < .05$.

² $X^2 = 30.17$, $df = 4$, $p < .001$.

The survey also asked respondents to complete data tables on current graduation and attrition rates for the following groups of students: (a) all undergraduate students; (b) undergraduate students majoring in science or engineering; (c) all graduate students; and (d) graduate students majoring in science or engineering.

In general, we hoped to determine average four- and five-year graduation and attrition rates. To calculate these rates, many institutions follow a cohort of incoming freshmen through the system. However, we did not impose any particular formula for calculating rates of graduation or attrition, but asked each institution to tell us how their calculations were performed. As suggested by Smith, methods and goals may not always be similar for all concerned parties: "Retention is an important measure of success, but it is complicated by a variety of definitions and by the variety of ways in which it is measured. Institutional retention, for example, is a very important measure of success for institutions but, from the standpoint of public policy, may be less critical than retention as measured by completion of a degree". (Smith 1989, 17).

Providing this data proved to be problematic for many of the institutions participating in the study. Many institutions did not routinely calculate it, and others reported that their databases would not allow them to calculate this information. A sizeable number of institutional representatives called to ask the project staff for information on how they could calculate attrition rates and what the term "attrition" meant. Rather than providing graduation rates, many institutions simply told us how many total students they had graduated in the previous year. In sum, the information gathered from the data tables was largely unusable.

However, we tabulated the percentages of institutions that could and could not provide this type of information, and those that were and were not able to provide separate rates by sex, racial/ethnic group, disability status, and major field of study (all majors versus science/engineering majors). The findings are presented in Tables 2.10, 2.11, and 2.12. Percentages reflect the institutions which could NOT provide rates in the particular categories.

Overall, rates were more available for undergraduate students than for graduate students and for students in all majors than for science/engineering majors (Table 2.10). In fact, attrition rates for graduate students in science/engineering were almost completely missing. Only 6% of the institutions responding provided any information in this category. Research Universities were most likely to provide information in these categories. From telephone conversations with many of the respondents, it was apparent that one key factor in whether an institution was able to provide this information was the extent to which student records were maintained on a flexible computer database and the length of time that the records had been maintained. Smaller institutions often did not have the ability to pull records and conduct these analyses via computer; many of these institutions pulled records and conducted analyses by hand in order to complete the surveys.

These rates also were not available for female students (Table 2.11) and minority students. Table 2.12 provides data for Black students; data for other racial/ethnic groups were similar. As expected, graduation and attrition rates for students with physical disabilities were rarely available; typically, less than 15% of the institutions in any category could provide this information.

None of the questions in this survey asked institutions to break out numbers of faculty or students, or graduation or attrition rates by both sex and racial/ethnic group simultaneously (for example, Black females, Black males). However, we did ask whether the information requested in the surveys would have been available in this form. As indicated in Table 2.13, the information would have been available most often for undergraduate students and faculty members and most often from Research Universities.

Summary and Recommendations

Responses to the *Survey of Presidents and Chancellors* provided an overview of some of the major institutional characteristics which can affect the recruitment and retention of underrepresented groups in science and engineering. These included: tuition rates and the availability of financial aid; flexibility in declaration of major field of study; campus policies which address sexual harassment, training for foreign graduate students, and access to services and physical facilities for students with disabilities; the availability and status of faculty members who can act as science/engineering role models for target group students; and the monitoring of student progress in science and engineering.

As detailed in Chapter 1, there are other factors related to the institution or the student which also affect recruitment and retention. These were not explored in the current study due to the limitations of the survey methodology and the size and diversity of the sample. However, they are worthy of further and more detailed study.

The data provided by the participating institutions indicate that there are differences among the various institutional types in how they approach the problem of recruiting and retaining underrepresented groups in science and

engineering. However, some of the findings suggest recommendations for action which should be useful to all institutions. These general findings and recommendations are described below.

1. Finding: At the responding institutions that could provide information (40%), science and engineering students were about equally likely to receive financial aid as were students in *all* majors.

Recommendation: Institutions should examine both the amount and type of financial aid received by science and engineering students by racial/ethnic group, by sex, and by physical disability. In addition, special consideration should be given to students who carry a heavy load of laboratory course work which requires more in- and out-of-class laboratory time. The nature of the science/engineering curriculum may make it difficult for students to put in adequate paid-work hours to supplement their financial aid.

2. Finding: Few institutions require students to declare their major field of study at the time of application or admission.

Recommendation: Institutions should continue to explore ways to encourage career exploration and flexibility in the curriculum to facilitate the post-secondary flow of students into science and engineering. Suggestions for specific action and descriptions of model programs for broadening the scope and sequence of science in the higher education curriculum are explored in the recent AAAS report, *The Liberal Art of Science* (AAAS 1990).

3. Finding: Many larger institutions had conducted studies of campus accessibility to students and faculty with physical disabilities.

Recommendation: Institutions that have not already done detailed studies should do so. Those institutions that have already conducted general access studies should initiate specific studies to examine access to science/engineering classrooms, laboratories, and equipment and intervention programs. Individual departments may need to conduct inventories of equipment that need modification for students with hearing, vision, or mobility impairments and consult with appropriate specialists so that accommodations for students with disabilities can be made quickly, utilizing the best available technology. Further, DSS staff members need opportunities to learn about and funds to obtain new technologies that can provide access to computer software and a wide variety of computers and scientific/engineering equipment. (For additional recommendations concerning students with physical disabilities, see (Chapter 4).

4. Finding: Nearly all of the institutions in this study have a stated policy on sexual harassment. The conduct of a study on campus climate for women and minorities was less common, especially at Liberal Arts Colleges or Professional/Other Institutions. Although most institutions that have foreign graduate students provide some type of training sessions for them, their impact on campus climate for women, minorities, and people with physical disabilities remains unclear.

Recommendation: A number of reports indicate that sexual harassment and racial discrimination continue to be prevalent on the nation's campuses (Shavlik et al. 1987; Maguire, 1988; Smith, 1989). Campus climate is not static; progress and regression occur and, as formal barriers to equity are removed, informal and more subtle barriers can continue to impede full participation of underrepresented or non-traditional groups of students, especially in science and engineering. Institutions of all types must renew their commitment to

providing campus environments that foster full participation—academically and socially—of all students. This requires regular and increasingly fine-tuned studies, implementation of appropriate policies, and training of faculty and staff.

5. Finding: With the exception of women's colleges and minority institutions, women and minorities continue to be underrepresented in science and engineering at higher education institutions. This is true even among the institutions in the current study—institutions that have good track records of equity efforts in this area. This is especially true for Research Universities and in higher-level faculty positions. The lack of information on the presence of faculty members with physical disabilities leaves their status unclear.

Recommendation: Increasing the number of females, minorities, and persons with physical disabilities on science and engineering faculties is difficult. It is not, however, impossible and the resulting benefits to the institution and to target group students on campus make it well worth the effort. Blackwell (1988) makes specific suggestions for recruitment and retention of minority faculty members, many of which also apply to women and persons with physical disabilities:

- Recruit aggressively, including obtaining lists of potential candidates from institutions that produce significant numbers of doctoral minorities and advertising in media outlets likely to be used, seen, or read by minorities.
- Use 'grow-your-own' programs where minority graduate students and postdoctoral fellows are prepared to take positions on the faculty of the same institution.
- Use postdoctoral fellowships to make permanent faculty positions more appealing to minority students just completing graduate studies and visiting professorships and endowed chairs to recruit senior faculty members.
- Provide support for travel to professional meetings.
- State tenure/retention requirements clearly during interviews and, subsequently, assign course loads that allow the faculty member to meet tenure expectations.
- Be prepared to pay market salary levels for minority faculty, and to deal with the difficulties this may create within the department.
- Assign and prepare senior faculty members to act as mentors for junior faculty members, including minority group members.
(P. 425–26)

Overall, institutions must make sincere—not superficial—efforts to recruit and retain female and minority faculty and those who either come to the institution with a physical disability or acquire one during their time at the institution. When members of these groups are absent from the faculty, fellow faculty members, the student body, and the institution as a whole suffer.

6. Finding: Although attrition and retention in science/engineering are often the subject of studies in higher education and are of obvious financial concern for higher education institutions, few institutions routinely monitor the attrition/retention of groups that are particularly at risk.

Recommendation: Institutions and specific science/engineering departments should monitor carefully the progress of students, especially female and minority students and those with physical disabilities, to determine where attrition is occurring. Further, careful investigation may be warranted to determine the causes of those losses.

In summary, previous studies have shown that the creation of an atmosphere which promotes diversity among the science and engineering faculty and student body requires a focus on many aspects of both academic and social life on campus. The current study suggests that the approach an institution takes toward creating an atmosphere for diversity may differ by institutional type. Regardless of the specific strategies used, however, institutional commitment is the required first step: "It appears, however, that high levels of institutional commitment tend to lead to the development of comprehensive strategies addressing a broad range of the causes and correlates of attrition" (Jones and Watson 1990, 70). ▀

Table 2.1
Response Rates for "Survey of Presidents and Chancellors" by
Institutional Type

Institutional Type	Percentage (number) of institutions surveyed	Percentage (number) of institutions responding	Response Rate
Research University	20% (100)	26% (72)	72%
Doctorate-Granting	13% (64)	16% (43)	67%
Comprehensive Colleges and Universities	39% (196)	38% (106)	54%
Liberal Arts Colleges	21% (105)	14% (39)	37%
Professional and Other	8% (38)	6% (16)	42%
Total	100% (503)	100% (276)	55%

Note: Percentages may not total 100% due to rounding.

Table 2.2
Institutions Providing Information on Climate Issues for
Women, Minorities, and Students with Disabilities, by
Institution Type

Institution Type	Percentage (number) of Institutions Responding Positively				
	Harassment Policy	Climate Study	Foreign TA ¹ Training	DSS ²	Campus Accessibility
Research University	96% (55)	72% (31)	79% (34)	93% (66)	86% (44)
Doctorate-Granting	96% (25)	68% (13)	53% (9)	85% (35)	70% (16)
Comp. Coll and Univ	85% (55)	53% (25)	20% (8)	81% (86)	66% (29)
Liberal Arts Colleges	76% (10)	32% (6)	0% (0)	29% (11)	35% (6)
Professional & Other	78% (7)	29% (2)	100% (1)	47% (7)	43% (3)
Total	88% (161)	56% (77)	50% (52)	76% (205)	68% (98)

Note. "Percentage" refers to percentage of institutions which responded to the question.

¹ Includes only institutions which indicated that they grant MS/MA, Ph.D. or other professional degrees.

² Disabled Student Services Office.

Table 2.3 Availability of Data on Faculty by Target Group

Faculty Position	Percentage (number) of Institutions Providing Data on		
	Women	Physically Disabled	Racial/Ethnic Groups
Total Full-Time Faculty	96.4% (266)	44.6% (123)	88.0% (243)
Full-Time Tenured Science/Eng.	87.3% (241)	41.7% (115)	84.4% (233)
Full-Time Tenure-Track Science/Eng.	85.5% (236)	39.5% (109)	83.0% (229)
Full-time Non-Tenure-Track Science/Eng.	73.2% (202)	32.2% (89)	69.2% (191)
Part-Time Science/Eng.	69.6% (192)	32.2% (89)	61.6% (170)

Table 2.4 Women as a Percentage of Faculty by Institution Type and Faculty Position

Faculty Position	Average Percentage of Faculty who are Female (Number of Institutions Responding)					
	Total	Research University	Doctorate- Granting	Compre- hensive	Liberal Arts	Prof. and Other
Total Full-Time Faculty ¹	27.7% (266)	19.7% (68)	22.0% (42)	30.8% (101)	40.3% (39)	27.0% (16)
Full-Time Tenured Faculty-Science/Eng. ²	12.1% (241)	5.7% (65)	5.8% (39)	14.4% (94)	23.4% (34)	20.1% (9)
Full-Time Tenure Track Faculty-Science/Eng. ³	21.1% (236)	15.6% (64)	16.9% (39)	23.8% (91)	28.3% (34)	25.9% (8)
Full-Time Non-Tenure Faculty-Science/Eng. ⁴	32.7% (202)	27.8% (60)	26.8% (35)	38.3% (72)	45.6% (21)	19.9% (14)
Part-Time Faculty Science/Eng. ⁵	28.0% (192)	20.3% (48)	23.4% (29)	32.4% (75)	37.3% (30)	16.6% (10)

¹ $F = 22.24$, $df = 265$, $p < .0001$.² $F = 9.69$, $df = 240$, $p < .0001$.³ $F = 4.18$, $df = 235$, $p < .01$.⁴ $F = 5.03$, $df = 201$, $p < .001$.⁵ $F = 3.74$, $df = 191$, $p < .01$.

Table 2.5 Blacks as a Percentage of Faculty in Non-HBCU Institutions, by Institution Type and Faculty Position

Faculty Position	Average Percentage of Faculty who are Black (Number of Institutions Responding)					
	Total	Research University	Doctorate Granting	Compre- hensive	Liberal Arts	Prof. and Other
Total Full-Time Faculty ¹	2.5% (5)	1.9% (66)	1.6% (40)	3.6% (72)	5.2% (30)	1.2% (12)
Full-Time Tenured Faculty-Science/Eng.	1.2% (207)	0.6% (64)	0.3% (38)	2.2% (72)	2.0% (24)	0.5% (9)
Full-Time Tenure Track Faculty-Science/Eng.	2.2% (67)	2.9% (65)	3.2% (36)	3.9% (70)	4.7% (25)	0.7% (8)
Full-Time Non-Tenure Faculty-Science/Eng.	3.4% (204)	2.5% (59)	1.6% (30)	2.4% (55)	12.5% (13)	1.4% (10)
Part-Time Faculty Science/Eng.	2.0% (145)	1.1% (44)	1.8% (22)	1.9% (52)	3.3% (20)	5.0% (7)

¹ $F = 1.83$, $df = 219$, $p < .05$.

Table 2.6 Hispanics as a Percentage of Faculty in Non-Puerto Rican Institutions by Institution Type and Faculty Position

Type and Faculty Position	Average Percentage of Faculty who are Hispanic (Number of Institutions Responding)					
	Total	Research University	Doctorate- Granting	Compre- hensive	Liberal Arts	Prof. and Other
Total Full-Time Faculty ¹	1.8% (239)	1.3% (67)	1.7% (40)	2.8% (85)	0.9% (37)	0.9% (10)
Full-Time Tenure Faculty- Science/Eng ²	1.1% (225)	0.8% (65)	0.8% (38)	1.8% (86)	0% (31)	2.4% (5)
Full-Time Tenure Track Faculty-Science/Eng.	2.0% (183)	1.2% (65)	2.2% (36)	1.8% (83)	0% (32)	1.8% (5)
Full-Time Non-Tenure Faculty-Science/Eng.	1.4% (221)	2.1% (38)	3.0% (24)	2.0% (61)	0.9% (22)	0% (0)
Part-Time Faculty Science/Eng.	1.2% (58)	1.0% (45)	1.7% (23)	1.8% (60)	0% (25)	0% (5)

¹ $F = 2.87$, $df = 238$, $p < .05$.

² $F = 3.24$, $df = 224$, $p < .05$.

Table 2.7 American Indians as a Percentage of Faculty by Institution Type and Faculty Position

Faculty Position	Average Percentage of Faculty who are American Indian (Number of Institutions Responding)					
	Total	Research University	Doctorate- Granting	Compre hensive	Liberal Arts	Prof. and Other
Total Full-Time Faculty	0.3% (235)	0.2% (66)	0.3% (40)	0.3% (87)	0.3% (35)	0.3% (12)
Full-Time Tenured Faculty-Science/Eng.	0.9% (233)	0.3% (65)	0.2% (38)	0.2% (90)	0.1% (31)	0.0% (9)
Full-Time Tenure Track Faculty-Science/Eng.	0.4% (227)	0.1% (65)	0.4% (36)	0.6% (86)	0.4% (32)	0.0% (8)
Full-Time Non-Tenure Faculty-Science/Eng.	0.3% (189)	0.1% (60)	0.4% (30)	0.3% (69)	0.4% (19)	1.0% (11)
Part-Time Faculty Science/Eng.	0.2% (157)	0.1% (44)	0.2% (20)	0.0% (61)	0.6% (25)	0.0% (7)

Table 2.8 Physically Disabled Persons as a Percentage of Faculty by Institution Type and Faculty Position

Faculty Position	Average Percentage of Faculty with Physical Disabilities (Number of Institutions Responding)					
	Total	Research University	Doctorate- Granting	Compre- hensive	Liberal Arts	Prof. and Other
Total Full-Time Faculty	0.9% (123)	9.2% (25)	1.0% (15)	1.1% (46)	0.6% (29)	0.9% (8)
Full-Time Tenured Faculty-Science/Eng.	1.1% (115)	1.4% (24)	1.1% (16)	0.9% (44)	1.4% (26)	0.7% (5)
Full-Time Tenure Track Faculty-Science/Eng.	0.4% (109)	0.5% (22)	0.4% (14)	0.2% (41)	0.6% (26)	0.0% (5)
Full-Time Non-Tenure Faculty-Science/Eng.	0.3% (89)	0.3% (22)	0.8% (12)	0.2% (33)	0.0% (15)	0.0% (7)
Part-Time Faculty Science/Eng.	1.2% (89)	0.4% (20)	1.5% (8)	1.0% (35)	2.5% (20)	0.4% (6)

Note: Less than half of the institutions participating in this study responded to these questions.

Table 2.9
Routine Calculation of Graduation Rates and Attrition Rates,
by Student Level and Institution Type

Institution type	Percentage (number) of Institutions which Routinely Calculate Rates for			
	Graduation of		Attrition among	
	Undergraduate Students ¹	Graduate Students ²	Undergraduate Students ³	Graduate Students ²
Research University	69% (49)	11% (8)	70% (50)	9% (6)
Doctorate-Granting	48% (20)	10% (4)	51% (21)	10% (4)
Comp. Coll and Univ.	46% (48)	15% (15)	47% (49)	16% (16)
Liberal Arts Colleges	64% (25)	12% (3)	67% (26)	8% (2)
Professional & Other	50% (8)	0% (0)	56% (9)	0% (0)
Total	55% (150)	12% (30)	57% (155)	11% (28)

¹ $\chi^2 = 11.68$, df, $p < .05$.

² Percentages do not include institutions that indicated that they do not have graduate students.

³ $\chi^2 = 11.84$, df = 4, $p < .05$.

Table 2.10 Availability of Graduation and Attrition Rates by Student Level, Major Field of Study, and Institution Type

Institution Type	Percentage (number) of Institutions which Could Not Provide Rates for							
	Undergraduate-All		Undergraduate-S/E		Graduate-All ⁴		Graduate-S/E ⁴	
	Graduation ¹	Attrition ²	Graduation	Attrition ³	Graduation	Attrition	Graduation	Attrition
Research University	24% (17)	26% (19)	56% (40)	58% (42)	76% (55)	79% (57)	82% (59)	91% (61)
Doctorate-Granting	51% (22)	56% (24)	72% (31)	81% (35)	81% (35)	84% (36)	86% (37)	98% (39)
Comprehensive	56% (59)	61% (65)	68% (72)	77% (82)	72% (76)	80% (85)	76% (80)	95% (88)
Liberal Arts	37% (14)	56% (22)	74% (29)	90% (35)	33% (13)	33% (13)	38% (15)	100% (26)
Prof. and Other	38% (6)	38% (6)	50% (8)	56% (9)	56% (9)	38% (6)	44% (7)	67% (6)
Total	43% (118)	49% (136)	65% (180)	74% (203)	68% (188)	71% (197)	72% (198)	94% (220)

Note: Undergraduate refers to full-time undergraduate students in "all" or "Science and engineering (S/E)" majors. "Graduate" refers to full or part-time graduate students in "all" or "science and engineering (S/E)" majors.

¹ $\chi^2 = 20.17$, $df = 4$, $p < .001$.

² $\chi^2 = 23.66$, $df = 4$, $p < .0001$.

³ $\chi^2 = 18.44$, $df = 4$, $p < .01$.

⁴ Statistical analysis not conducted due to small cell sizes.

Table 2.11 Availability of Graduation and Attrition Rates for Female Students by Student Level, Major Field of Study, and Institution Type

Institution Type	Percentage (number) of Institutions which Could Not Provide Rates for							
	Undergraduate-All		Undergraduate-S/E		Graduate-All ⁴		Graduate-S/E ⁴	
	Graduation ¹	Attrition ²	Graduation	Attrition ³	Graduation	Attrition	Graduation	Attrition
Research University	44% (32)	50% (36)	62% (45)	65% (47)	81% (58)	83% (60)	83% (60)	85% (61)
Doctorate-Granting	72% (31)	77% (33)	79% (34)	88% (38)	84% (36)	88% (38)	86% (37)	91% (39)
Comprehensive	66% (70)	76% (80)	76% (80)	87% (92)	76% (80)	83% (88)	78% (83)	86% (91)
Liberal Arts	44% (17)	62% (24)	74% (29)	90% (35)	36% (14)	36% (14)	38% (15)	36% (14)
Prof. and other	56% (9)	56% (9)	56% (9)	62% (10)	50% (8)	44% (7)	44% (7)	38% (6)
Total	58% (159)	66% (182)	71% (197)	80% (222)	71% (196)	75% (207)	73% (202)	76% (211)

Note: Undergraduate refers to full-time undergraduate students in "all" or "science and engineering (S/E)" majors. "Graduate" refers to full or part-time graduate students in "all" or "science and engineering (S/E)" majors.

¹ $\chi^2 = 15.04$, $df = 4$, $p < .01$.

² $\chi^2 = 15.67$, $df = 4$, $p < .01$.

³ $\chi^2 = 20.37$, $df = 4$, $p < .001$.

⁴ Statistical analysis not conducted due to small cell sizes.

Table 2.12 Availability of Graduation and Attrition Rates for Black Students by Student Level, Major Field of Study, and Institution Type

Institution Type	Percentage (number) of Institutions which Could Not Provide Rates for							
	Undergraduate-All		Undergraduate-S/E		Graduate-All		Graduate-S/E	
	Graduation ¹	Attrition ²	Graduation ³	Attrition ⁴	Graduation	Attrition	Graduation	Attrition
Research University	32% (23)	33% (24)	60% (43)	62% (45)	79% (57)	83% (60)	83% (60)	86% (62)
Doctorate-Granting	67% (29)	70% (30)	77% (33)	91% (39)	81% (35)	88% (38)	84% (36)	91% (39)
Comprehensive	69% (73)	79% (84)	80% (85)	90% (95)	77% (82)	85% (90)	81% (86)	87% (92)
Liberal Arts	51% (20)	80% (31)	69% (27)	92% (36)	28% (11)	46% (18)	28% (11)	46% (18)
Prof. and other	62% (10)	69% (11)	69% (11)	69% (11)	38% (6)	44% (7)	31% (5)	38% (6)
Total	56% (155)	65% (180)	72% (199)	82% (226)	69% (191)	77% (213)	72% (198)	79% (217)

Note: Undergraduate refers to full-time undergraduate students in "all" or "science and engineering (S/E)" majors. "Graduate" refers to full or part-time graduate students in "all" or "science and engineering (S/E)" majors.

¹ $\chi^2 = 26.96$, $df = 4$, $p < .0001$.

² $\chi^2 = 45.44$, $df = 4$, $p < .0001$.

³ $\chi^2 = 9.64$, $df = 4$, $p < .05$.

⁴ $\chi^2 = 29.48$, $df = 4$, $p < .0001$.

Table 2.13
Availability of Information on Students and Faculty by Sex and Racial/Ethnic Group Simultaneously, by Student Level and Institution Type

Institution Type	Percentage (number) of Institutions Responding Positively		
	Undergraduate Students ¹	Graduate Students	Faculty Members ²
Research University	79% (56)	59% (42)	86% (59)
Doctorate-Granting	71% (30)	64% (27)	85% (35)
Comp. Coll and Univ	59% (63)	50% (53)	66% (69)
Liberal Arts Colleges	46% (17)	14% (5)	76% (28)
Professional & Other	31% (4)	8% (1)	38% (5)
Total	63% (170)	48% (128)	74% (196)

¹ $\chi^2 = 19.98$, $df = 4$, $p < .001$.

² $\chi^2 = 26.42$, $df = 8$, $p < .001$.

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Programs for Women and Minorities: Creating a Clear Pathway for Future Scientists and Engineers



Marsha Lakes Matyas

In the ideal, students and faculty of both sexes and all racial/ethnic groups would be encouraged and supported to pursue career options in all fields, including science and engineering. There would be no socio-cultural barriers or norms to discourage students or young professionals. Rather, children would have opportunities to explore a wide range of occupations and types of work and possess the educational experiences that would keep a variety of career options open well into the undergraduate years. Unfortunately, current reality does not match this scenario. As detailed in Chapter 1, there are a variety of educational and social factors that make the pathway to a career in science and engineering more elusive for female and minority students than for White male students.

Efforts to open up the pathway to science and engineering careers for underrepresented groups have typically taken the form of *intervention programs*. Intervention programs usually consist of a series of activities that are organized for a specific group of participants in order to address one or more specific factors that affect females' or minorities' interests, motivation, or skills in science, mathematics, or engineering. For example, a one-day career fair is organized to bring middle school children in contact with female and minority science and engineering role models so that they can: (1) experience hands-on science activities; (2) learn about careers in science and engineering; (3) encounter positive role models of the same sex and/or racial/ethnic group; and (4) learn what steps they should take during middle and high school to pursue a career in science or engineering. Science, mathematics, and engineering intervention programs targeted at women and/or minorities have been active since the 1960's at both the precollege and the undergraduate levels.

Overview of Precollege Programs

In 1983, the AAAS Office of Opportunities in Science conducted an assessment of precollege programs that facilitated increased access and achievement of females, minorities, and students with physical disabilities in K-12 mathematics and science education (Malcom 1983). Over 300 programs were surveyed and, of the 168 programs for which data were received, colleges and universities housed half of the projects focusing on women and two-thirds of those focusing on minority students. Nearly half of the projects were targeted exclusively at senior high school students.

Most of the projects were at least partially supported by the host institution, but nearly all received external funding, as well. For women's projects, the top three funding sources were industry, private foundations, and student fees for the program. For minority programs, industry, foundations, and the National Science Foundation were the top three sources of funding.

A variety of program types were identified that addressed many of the factors described in Chapter 1. Long-term programs tended to focus on the development of higher-level cognitive skills related to problem-solving, understanding, and applications; hands-on experiences were common to most programs to increase confidence and familiarity with scientific and engineering methods and tools. Components on career information, exposure to role models, test-taking skills, and financial aid were typically included, as well. These programs usually involved teachers and counselors and resulted in an improved overall learning environment for the targeted students as well as improved skills, confidence, and interest for the individual student. Short-term projects usually focused on providing career information or course information relevant to students, teachers, and/or parents. This information was often conveyed by role models. There was sometimes an opportunity for limited hands-on activities and demonstrations. These programs appeared to be most effective when other systems were present in the community after the intervention program was completed to support the students' information and educational needs. Overall, exemplary academic-based programs include a number of distinctive characteristics. Some of these are listed below:

- a strong academic component in mathematics, science, and communications focused on enrichment rather than remediation;
- academic subjects taught by instructors who are highly competent in the subject matter and believe that students can learn the materials;
- heavy emphasis on the applications of science and mathematics, and on careers in these fields;
- an integrative approach to teaching that incorporates all subject areas, hands-on opportunities, and computers;
- multi-year involvement with students;
- a strong director and committed and stable (low turnover) staff who share the program goals;
- a stable, long-term funding base with multiple funding sources so that staff do not spend large portions of their time searching for support;

- recruitment of participants from all relevant target populations in an area;
- cooperative activities with a university, industry or school;
- opportunities for in-school and out-of-school learning experiences;
- parental involvement, and development of a base of community support;
- specific attention to removing educational inequities related to gender and race;
- involvement of professionals and staff who look like the target population;
- development of peer support systems by involvement of a "critical mass" of female and/or minority students;
- evaluation, long-term follow-up, and careful data collection; and
- "mainstreaming"—integration of program elements supportive of women and minorities into the institutional programs (Malcom 1983, 14)

Overview of Undergraduate and Graduate Efforts

Unfortunately, no study of undergraduate and graduate programs analogous to the AAAS precollege study has been completed. Guide books for minority (Johnson 1980) and female students (Howe, Howard, and Strauss 1982; Bogart 1984) provide some information on services and scholarships available at colleges and universities. A few national guides have been published for minority students interested in engineering careers (NACME 1986, 1988; Adams 1985), but there are few guides for women or minorities that specifically discuss science programs, and no comprehensive studies of programs at higher education institutions.

The best collection of information on minority programs at the undergraduate level is provided by the National Action Council for Minorities in Engineering (NACME). In 1985, NACME commissioned the National Association of Minority Engineering Program Administrators (NAMEPA) to document how support programs for underrepresented minority students within colleges and schools of engineering should be developed (Landis 1985). Unfortunately, their study did not include science programs, but some parallels can certainly be drawn.

The 1984 NACME directory of 148 precollege programs included many programs that function both at the precollege and undergraduate levels (NACME 1984). Programs for minorities in engineering received funding from a variety of sources, including NACME, the U.S. Department of Energy, the National Science Foundation, private foundations, and industry (Blackman in Landis 1985).

Minority engineering programs addressed both academic and attitudinal barriers that prevent minority students from earning engineering degrees. Specifically, the NACME study determined that model minority engineering programs contain the following components: (1) recruitment of students from high schools and two-year colleges; (2) monitoring of and assisting in

admissions procedures; (3) assisting in student matriculation (including financial aid acquisition and budgeting, housing, diagnostic testing, academic advising, registration, and orientation); (4) providing academic support (including tutoring, study skills training, shadow courses or extra recitations, and course selection assistance); (5) providing a student study center; (6) linking students with student organizations such as the National Society of Black Engineers, the Society for Hispanic Professional Engineers, and the American Indian Science and Engineering Society; and (7) involving students in summer engineering jobs.

As stated earlier, a comprehensive listing and/or analysis of minority undergraduate programs in science has not been completed. Certainly federal programs such as MARC (Minority Access to Research Careers) and MBRS (Minority Biomedical Research Support Program) have been effective in increasing the persistence of minority participants in the sciences (Garrison and Brown 1985).

Similarly, a comprehensive study of undergraduate programs for women in science and engineering has not been conducted. Unlike NACME and NAMEPA which serve as national organizations for minority engineering programs, until recently, there was no national coordinating organization for programs targeted at women in science or engineering. In 1990, however, women in engineering program directors at Purdue University, Stevens Institute of Technology, and the University of Washington established the Women in Engineering Program Advocates Network (WEPAN). The goal of WEPAN is to facilitate the recruitment, admission, retention, and graduation of women engineering students. Network activities focus on assisting and encouraging engineering schools throughout the United States to establish innovative programs for women in engineering or to expand the scope of existing programs.

According to a 1987 survey of prospective WEPAN members, the number and types of women in engineering program activities has significantly declined over the last decade (Daniels 1990). With the exception of freshman scholarships and graduate fellowships, all types of program activities focused on the recruitment and retention of women in engineering declined nationally between 1982 and 1987. These activities included student chapters of the Society of Women Engineers, availability of recruitment brochures and information, programs for teachers and counselors, career conferences, summer programs, and junior high outreach activities. This decline in activities focusing on women in engineering corresponds to the decline in the number of female freshman engineering students nationally, which also began in 1982 (AAES 1989). Therefore, while the national need for women scientists and engineers is increasing, the number of women enrolling in engineering studies is decreasing and the efforts to recruit and retain them are becoming more sparse.

Additional information on programs for women can be drawn from a study by Bogart (1984), which identified 138 programs housed at undergraduate institutions in 26 states. The study does not describe a nationally representative sample, however, since programs from only 56 institutions were included in the study and only six institutions housed nearly half (46%) of the programs listed.

Like precollege programs, the programs in this study received partial support from the institution, but many also relied upon external funding, particularly for the initial development of the program. The Fund for the Improvement of Postsecondary Education, private foundations, and private endowments were the most common sources of funding. Other governmental funding

agencies also contributed, including the National Science Foundation, the Women's Educational Equity Act Program, and the then, U.S. Department of Education's National Institute for Education.

Perhaps the most significant aspect of Bogart's study is the outline it provides of the variety of programs undergraduate and graduate institutions have made available for women. Briefly, student program types include those addressing admissions, continuing education, financial aid, academic programs (including science and engineering programs), student development, counseling, and support services. A wide variety of programs and services affecting faculty and staff have been developed, as well. Unfortunately, Bogart's study identified only 23 undergraduate programs that specifically addressed women in science and/or engineering. The programs were primarily support (networking) programs for women in science and engineering majors (35%), or programs to stimulate incoming or current students in non-traditional fields (22%); but a considerable number were computer training programs for re-entry or staff women (22%).

In summary, research on undergraduate and graduate programs for minorities and women in science and engineering includes isolated studies and fragmented data, but has not produced a comprehensive view of either the status of the target groups in terms of retention or the extent and effectiveness of programs meant to increase their participation and retention in these fields. A more comprehensive study, therefore, was needed to compile and analyze information describing current efforts by higher education institutions to recruit and retain women and minorities in these fields.

Methodology for the Current Study

A survey was developed to assess a variety of characteristics of programs and services used to recruit and retain female and minority students in science and engineering. Specifically, the survey questions focused on four areas:

1. The goals, history, and structure of the program
2. The target group of participants by sex, racial/ethnic group, educational level, and field of study
3. The program's impact via reported evaluation, publication, and dissemination
4. The program's funding, staffing, and place within the institutional structure

The draft version of the survey was reviewed by members of the AAAS Committee on Opportunities in Science and by several intervention program directors. Revisions were made and the final survey printed.

Sample Description

As detailed in Chapter 2, the presidents and chancellors of the participating institutions provided the names of contact persons for programs and services on their campuses that were involved in the recruitment and/or retention of female and/or minority students or those with physical disabilities in science and/or engineering. Information on over 900 programs and services were provided by the responding presidents and chancellors. Some of the contact persons were affiliated with Disabled Student Services Offices. These contact

persons received "Survey 2B: Programs and Services for Physically Disabled Students at Selected Institutions of Higher Education." Results of that survey are reported in Chapter 4. An additional subset of remaining programs was eliminated from the study for a variety of reasons, primarily lack of relevance to the study. The remaining sample of 721 program contact persons received a copy of "Survey 2B: Programs for Women and Minorities at Selected Institutions of Higher Education." This sample is described more fully below. Due to the size of the sample, no follow-up measures were used to increase response rates.

From the information provided by the presidents and chancellors, the 721 programs in the final sample were categorized according to the primary educational level of the participants and, where it could be determined, by the specific type of program. Six categories were used.

1. Precollege programs, grades K-12
2. General undergraduate programs for recruitment and retention
3. Undergraduate science and engineering programs
4. General graduate programs for recruitment and retention
5. Graduate science and engineering programs
6. Faculty recruitment and retention programs

Over 40% of the programs listed by presidents and chancellors were general undergraduate recruitment/retention programs, not programs specifically focusing on science and/or engineering.

Overall, nearly half (47%) of the programs surveyed responded. Response rates varied both by the type of program and type of institution (see Figure 2.1, pg 39 for description of institutional types). Research Universities and Comprehensive Colleges and Universities housed over two-thirds of the programs in the sample and also had the highest response rates (64% and 42%, respectively). Professional/Other Institutions provided the names of a few contact persons (N=22) but only five of these responded to the survey. Similarly, Liberal Arts Colleges listed only 69 contact persons for programs and only 26% (N=18) responded. Response rates were very high for undergraduate and graduate science and engineering programs (93% and 64%, respectively). Precollege programs also responded well. In fact, many precollege program directors duplicated the survey and sent it on to additional precollege program directors at their institution who were not on the sample list; therefore, the response rate for precollege programs was over 100%. Although the response rate for general undergraduate programs was low (24%), the initial sample size was large; therefore, the study includes information on a sizeable number of programs (N=77).

Programs designed to recruit and/or retain women and minorities were most likely to be found at Research Universities (Figure 3.1). Half of the programs responding were housed at Research Universities and an additional 30% were at Comprehensive Colleges and Universities. Programs were rarely found at Liberal Arts Colleges or Professional/Other Institutions (7% total), even at the precollege or undergraduate levels. Not surprisingly, Research Universities housed the large majority of graduate programs (76%), but they also housed over half of the general undergraduate programs and over 40% of

the precollege and science/engineering undergraduate programs. Comprehensive Colleges and Universities housed nearly 40% of the undergraduate science/engineering programs.

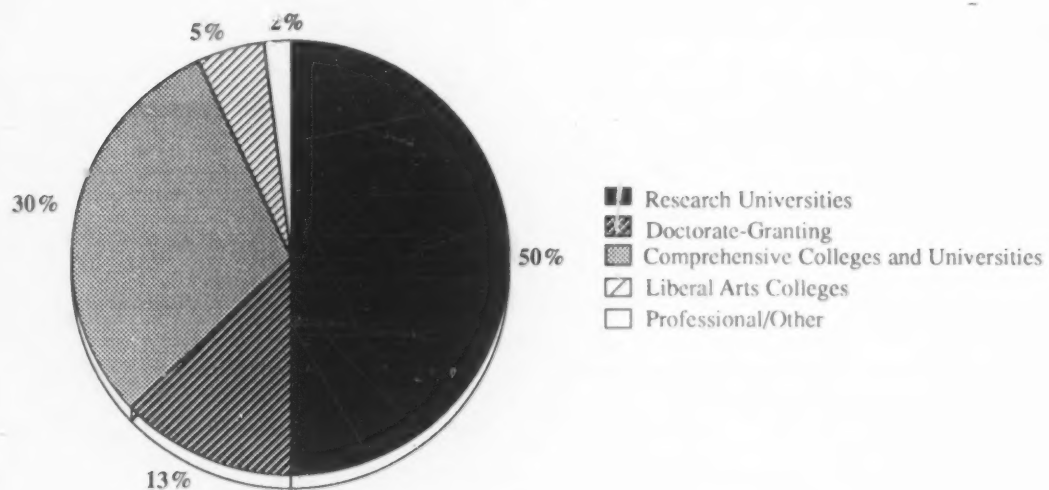
Program Types

After reading the descriptions of the individual programs, each was classified as to the primary educational level of participants and the specific type of program. Most of the programs responding primarily targeted students at the undergraduate level (57%) (Figure 3.2). The largest group of programs were those focusing on undergraduates in science and/or engineering. Very few programs responded which focused on general graduate recruitment and retention.

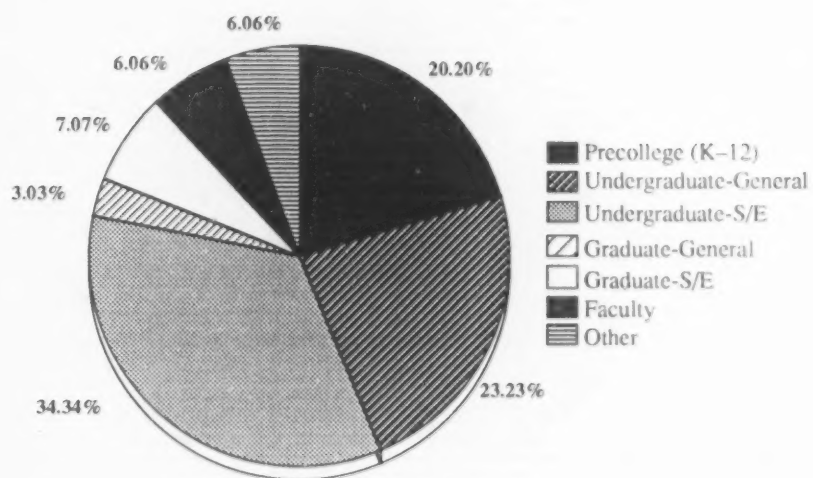
Precollege Programs

Within each general category of programs, individual programs were categorized by specific type. Precollege programs generally were one of five types:

1. High school science and/or engineering programs conducted during the school year including after school and Saturday academy programs (35%, N = 24)
2. Summer programs in science and/or engineering typically residential programs where students spend one to several weeks on campus (26%, N = 18)
3. Career fairs and outreach recruiting programs where institutional personnel travel to schools or bring students to campus to provide information on future career opportunities (24%, N = 16)
4. High School Research Apprenticeship Programs (sponsored by the U.S. Department of Health and Human Services) where students have opportunities to engage in research projects with assistance from scientists and engineers on campus (13%, N = 9)
5. Teacher inservice programs where K-12 teachers upgrade their content and methods skills (2%, N = 1)

Figure 3.1 Percentage of Programs by Institutional Type

Note: $\chi^2 = 34.65$, $df = 24$, $p < .05$.

Figure 3.2 Percentage of Programs by Program Type

General Undergraduate Programs

At the undergraduate level, programs were grouped into general programs and those that specifically focus on science and/or engineering. Among the General Undergraduate programs, there were seven specific types:

1. General retention programs that provided academic support and counseling, usually for underserved or at-risk students (27%, N = 21)
2. General recruitment and admissions programs which usually had special services for minority or at-risk students (26%, N = 20)
3. Office of minority affairs that focused on various issues, policies and activities affecting minority students and staff on campus (20%, N = 15)
4. Tutoring and study skills courses/centers where students learn study skills or receive tutoring in specific subjects (12%, N = 9)
5. Office of women's affairs that focusing on various issues, policies, and activities that affect women on campus (8%, N = 6)
6. Cultural centers, such as a Black cultural center, that coordinate activities related to specific ethnic cultural groups (5%, N = 4)
7. Women's studies programs that support various activities and courses focusing on women (3%, N = 2)

Undergraduate Science and Engineering Programs

Over a third of the responding programs were undergraduate programs that specifically focused on the fields of science and/or engineering. There were a number of program types:

1. Engineering recruitment and retention programs (34%, N = 40)
2. Science and engineering recruitment and retention programs, focusing on recruiting students in a variety of fields (18%, N = 21)
3. Minority Access to Research Careers (MARC) (10%, N = 12) and Minorities in Biomedical Research Support (MBRS) (8%, N = 9); national programs sponsored by the National Institutes of Health which provide support for undergraduate and graduate minority students to conduct biomedical research at institutions with substantial percentages of minority students
4. Scholarships for students in science and/or engineering fields (10%, N = 9) of the undergraduate science/engineering programs
5. Bridge programs to assist students in the transition from high school to college, usually during the summer months (7%, N = 8)
6. Campus chapters of professional associations such as the Society of Women Engineers, and the National Society of Black Engineers) (6%, N = 7)

7. Programs to introduce undergraduate students to research experiences, that are not part of a national program such as MARC or MBRS (3%, N=4)
8. Science/mathematics learning centers where students can seek assistance specifically in science and mathematics subjects (3%, N=3)
9. President/Chancellor's task force on recruiting underrepresented groups into science/engineering and/or institutional studies on access to science/engineering by underrepresented groups (2%, N=2)
10. Re-entry program where students have an opportunity to return to studies in science/engineering or switch fields in to science/engineering after being in the work force for a period of time (1%, N=1)

Graduate Programs

At the graduate level there were far fewer programs than at the undergraduate level. These programs were also divided into general and science/engineering categories. The general group includes ten general graduate recruitment and admissions programs, not specifically focusing on science or engineering.

Among the graduate programs focusing on science and/or engineering, there were five major categories:

1. Fellowships for research (44%, N=10)
2. Health Careers Opportunities Program (HCOP) which provides scholarships for students in training for health professions (22%, N=5)
3. Graduate recruitment and retention programs in science and/or engineering (17%, N=4)
4. Seminars for graduate students who will work as teaching assistants (9%, N=2)
5. Bridge programs to assist students in the transition from undergraduate studies to graduate studies, typically held during the summer months (9%, N=2)

Faculty Programs

Very few institutions reported having specific programs to recruit or retain faculty members from underrepresented groups. Generally, these efforts fell into one of three categories:

1. Science/engineering faculty recruitment effort (71%, N=15)
2. Affirmative action office or office of professional development (24%, N=5)
3. Faculty women/minority association (5%, N=1)

Finally, a number of academic departments ($N=21$) partially completed surveys, but their information typically described the department in general rather than specific strategies, policies, or activities to recruit and/or retain target group students. This information was not included in the following analyses.

Program Characteristics

The survey requested that contact persons for each program provide a variety of information on the program's goals, strategies, staffing, funding, participants, evaluation, and overall history. This information was examined using the criteria for effective intervention programs (described above) as guides for the data analysis. Many of the program characteristics varied by the program type and by the target population for the program (that is, women and/or minorities). Findings for each program characteristic are described below.

Target Population

In general, programs focusing on minority students were more common than those focusing on women (Table 3.1). Over half of all the programs responding to the survey were targeted at minority students or faculty. This included both programs that were targeted exclusively at minority group members or at "all students with special efforts for minorities." This was true for programs at the precollege, undergraduate, and graduate levels. Programs targeted at both women and minorities accounted for an additional 28% of the responding programs. However, very few programs were targeted exclusively at women (or at "all students with special efforts for women"); overall, less than 10% of the programs responding fit into this category. At the graduate level, only one program was targeted at women.

The survey also asked whether the program included activities for parents of students. Not surprisingly, graduate (10–12%) and faculty (5%) programs were unlikely to include activities for parents. However, while 52% of precollege programs and 49% of general undergraduate programs included parent components, significantly fewer undergraduate science and engineering programs did (30%). Overall, 34% of the responding programs included parent components.

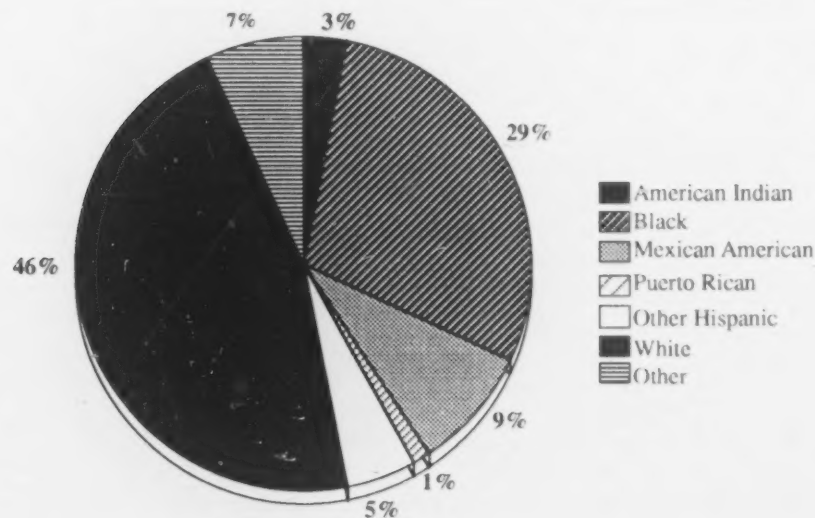
Since intervention programs are sometimes limited to a particular field such as engineering or microbiology, the survey also determined the specific fields in science/engineering that were included in the program. Overall, about 60% of the programs included computer science, engineering, life sciences, mathematics, and physical sciences. Environmental sciences were less likely to be included, especially in undergraduate science/engineering programs (25%) and precollege programs (41%). Also, undergraduate science/engineering programs were more likely to involve engineering than any other field (65%); this is not surprising since many of the programs were exclusively engineering recruitment/retention programs (see Program Types above).

Participants

The number of participants involved in each program varied according to the specific program type. In sum, 144,739 participants were involved in the 336 programs responding to the survey. As shown in Figure 3.3, White participants

and Black participants accounted for 75% of program participants. Hispanics accounted for an additional 15%, but American Indians accounted for only 3%. The proportion of Black program participants was consistently high among all of the program types with the exception of faculty programs. Faculty programs had a significantly higher proportion of White participants than did the other program types.

Figure 3.3 Racial/Ethnic Distribution of Total Program Participants



In looking at the program participant data, two primary questions were asked: "Do programs targeted at women serve minority students (that is, minority women)?" and "Do programs targeted at minority students serve women?" To answer the first question, the racial/ethnic distribution of participants by the target group of each program was examined (Table 3.2). Programs targeted at women had especially low average percentages of Black (7%) and Hispanic (8%) participants and those targeted at "women and minorities" had lower average percentages of Black (40%) and Hispanic (14%) participants than did programs targeted at minorities only or "all students with special efforts for minorities" (58% for Blacks and 19% for Hispanics). A similar pattern occurred for American Indians while the pattern was reversed for Whites. Programs for women had high percentages of White participants (70% on average) and programs for minorities had low percentages of White participants (8%). In summary, programs targeted at "minorities only" or "all students with special efforts for minorities" had the highest percentages of

minority participants, those for "women only" or "all students with special efforts for women" involved low percentages of minorities. Programs targeted at "women and minorities" lie somewhere in between. Therefore, programs targeted at women do not serve minority students very well.

The second question remains: "Do programs targeted at minority students serve women?" Results indicate that they do, but with room for improvement, especially among certain minority groups. First, the availability of data by both race and sex simultaneously was problematic for programs as it was for institutions (Chapter 2). Over 20% of the sample of programs could not provide data on numbers of male versus female participants and nearly 25% could not provide data on women in the various minority groups. Programs targeted at women were especially likely to lack information on minority women participants (33%). Therefore, the information presented below represents a reduced sample size due to the availability of data.

The average percentage of female participants in programs targeted at minorities is 51% (Table 3.3). However, this is not consistent among the racial/ethnic groups. On average, women comprise only 38% of both the American Indians and Puerto Ricans, 43% of the Mexican Americans, and 44% of the other Hispanics involved in programs targeted at minorities. Women in these four racial/ethnic groups were also underrepresented in programs targeted at women and minorities. Therefore, programs for minorities and for women and minorities seem to do a good job of recruiting Black women into their activities (53%) but are not as successful with Hispanics and American Indians.

Students with physical disabilities typically are not the primary target for science/engineering programs. However, the current survey attempted to determine whether these students were involved in programs targeted at women and minorities. Students with physical disabilities comprised only 0.7% ($N=1,018$) of the total participants in over 350 programs responding. With the exception of general undergraduate programs (32%), less than 15% of the other programs had at least one student with a physical disability among their participants in the year reported. Additional information concerning the participation of students with physical disabilities in programs for women and minorities is provided in Chapter 4.

The program types differed in the amount and frequency of contact they had with program participants (Table 3.4). Precollege and undergraduate programs (both general and science/engineering) were most likely to have frequent contact with participants. In fact, 64% of precollege programs and 59% of undergraduate science/engineering programs involved students in program activities at least once each week. Graduate and faculty level programs were most likely to meet on an "as needed" basis. Interestingly, the frequency of contact with participants also differed by target group. Programs targeted at women were much less likely to meet with participants at least once per week (33%) than were programs targeted at minorities (59%) or women and minorities (54%). Therefore, participants involved in programs at the graduate and faculty levels, or in programs targeted at women, have fewer opportunities to be involved in program activities.

Staffing and Funding

In Malcom's (1983) study of effective precollege programs, one of the key factors in successful programs was the program staff—their commitment and their effectiveness. Although it would be difficult to assess these characteristics

via written survey, some characteristics of the program staffs could be determined. On average, programs employed 3.9 full-time staff and 4.1 part-time staff. Half of the programs employed part-time students, usually employing one to ten total students (38% of programs). There were no significant differences among the various program types in the number or full/part-time status of employees hired, but the staffing patterns by racial/ethnic group and by sex were of interest.

The percentages of minority employees in programs were distributed dichotomously, that is, programs tended to have either high or low percentages of minority employees. This was true for both full-time and part-time employees (Figure 3.4). The distribution of minority and female employees differed by the program target group, as well (Table 3.5). Programs targeted at minorities had high percentages of minority employees and moderate proportions of female employees. Programs targeted at women had low percentages of minority employees, but high percentages of female employees. The specific job description for the program employees was not detailed. However, according to Malcom, staff in effective intervention programs function as role models for participants, often just by being successful, professional employees at a college or university. Therefore, the presence of target group-appropriate staff members may play a key role in the success of these programs.

In addition to paid staff, many programs utilize student (40%) and/or faculty (56%) volunteers. Use of volunteers differs somewhat by program type. General undergraduate programs were most likely to use student volunteers (59%), probably as tutors. Faculty programs were most likely to involve faculty volunteers (73%), but about half of all other program types used faculty volunteers, as well. In terms of numbers of volunteers, the combined programs involved 2,133 faculty and 2,052 students in volunteer activities. Programs were not only more likely to use faculty compared to student volunteers, but the average number of faculty members involved was somewhat larger, as well. On average, programs which involved volunteers had 19.1 faculty volunteers and 14.4 student volunteers. Finally, there were differences among the program target groups in use of volunteers, as well (Figure 3.5). Programs targeted at women were especially likely to utilize faculty and student volunteers, compared to programs for minorities or women and minorities. They also used more volunteer faculty members (mean=35.0) than did programs for minorities (mean=10.5) or women and minorities (mean=11.4).

Most of the programs responding to the survey (79%-95%, depending upon program type) had been in continuous operation since their inception. Total years of operation ranged from one year to 25 years, with an average of 7.9 years (s.d.=5.66 years). There were no significant differences among the program types in total years of operation. Averages ranged from 6.6 years for general graduate programs to 9.6 years for general undergraduate programs.

Yearly budgets varied widely from program to program. Some programs functioned without a specified budget while others had dollar amounts in the millions. There were no statistical differences between the six program types on the average yearly budget; however, precollege programs and faculty programs had the lowest overall average budgets (means=\$79,066 and \$73,859, respectively) and faculty programs had a much smaller range of yearly budgets with a maximum of \$201,000.

Figure 3.4 Minorities as a Percentage of Full-time and Part-time Employees

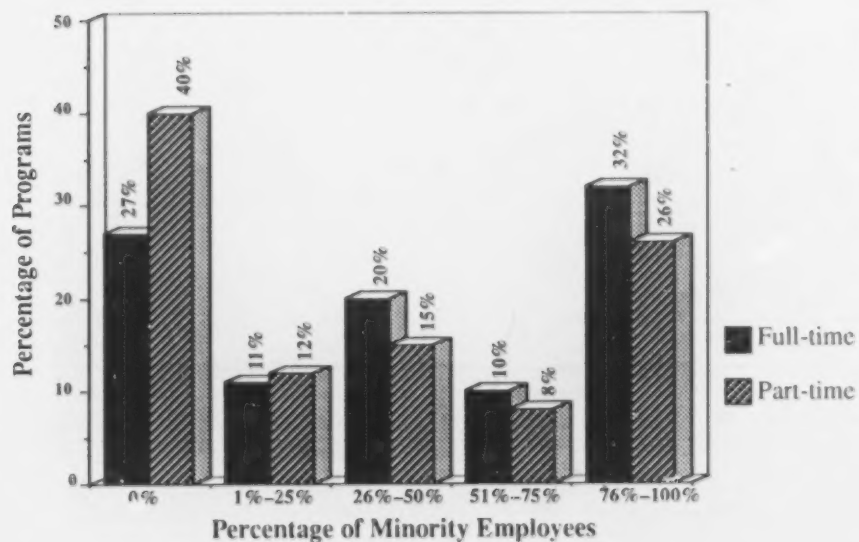
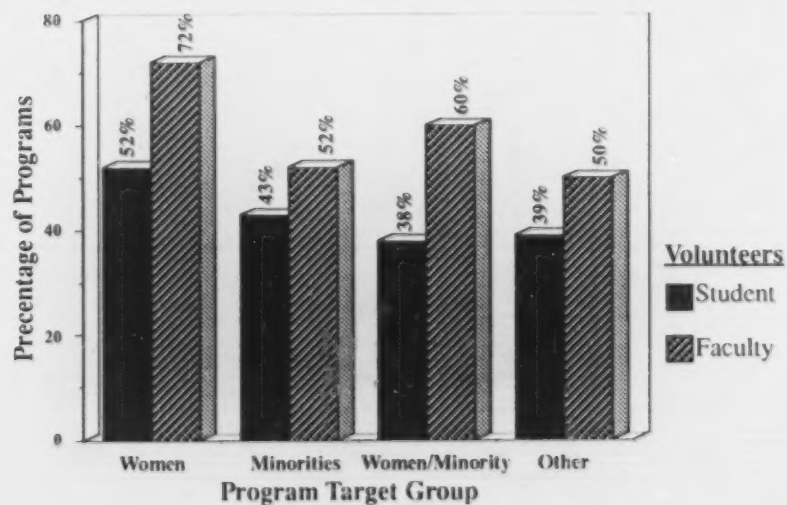


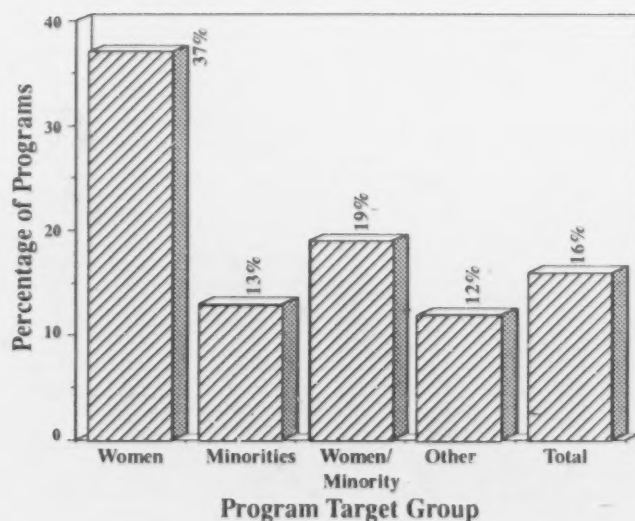
Figure 3.5 Use of Faculty and Student Volunteers, by Program Target Group



Sources of funding were also explored by the survey. On average, in their most recent year, programs received 42% of their funds from the host institution, 20% from federal grants, 16% from state grants, 12% from grants from business or industry, 5% from private foundations/sources, and 4% from other sources. However, 51% of programs responding depended upon a single source of funds, and an additional 34% depended on only two sources of funding. Less than 15% of the programs had a diverse funding base of three or more sources. This was consistent among the program types and the programs targeted at women versus minorities. Faculty programs (65%), and general undergraduate (61%) and graduate (49%) programs received the highest proportions of funding from the host institution while undergraduate and graduate science and engineering programs received the highest proportions of federal funds. Precollege programs, as a whole, had the most balanced funding profile with significant amounts of funding coming from the host institution, federal and state grants, and donations from business and industry.

Some programs (16%) also generated support by charging fees from participants. Programs targeted at women were significantly more likely to charge fees than were programs targeted at minorities or at women and minorities (Figure 3.6). When programs charge fees, they often offer financial aid for students who cannot afford to pay. Among those programs that charge fees, a large proportion indicated that financial aid was available for a number of services, if included in the program activities: room and board (87%); tuition (98%); stipend (88%); daily transportation (65%); and lunch (76%).

Figure 3.6 Programs which Charge Participant Fees, by Program Target Group



Evaluation

As described earlier most intervention programs have not been evaluated extensively. The current survey asked contact persons to report whether their program/service had ever been evaluated, and what the results of that evaluation were. Between 40 and 50% of precollege and undergraduate programs had done some type of formal report or longitudinal analysis of their program's effectiveness. Graduate programs were just as likely to have done an informal tally of the students served by the program as to have done a more formal evaluation of the program (23% each). A large proportion of the programs (38%) indicated that they had done some type of evaluation but did not provide any further information. This was especially true for general graduate recruitment programs (67%) and for undergraduate science and engineering programs (48%).

Respondents also were asked to detail which components of their program seemed to be most effective and which were least effective in accomplishing the program's goals. The most effective components/strategies are listed below in the approximate order of their frequency.

- Overnight, residential, and/or summer programs (N=22) were listed. Undergraduate science/engineering programs were most likely to cite this component as critical in their success.
- One-on-one interaction with faculty members (N=19) were cited, especially by precollege and undergraduate science/engineering programs.
- Hands-on laboratory experience (N=17) was mentioned, most frequently by precollege programs.
- Active recruitment and identification of potential program participants (N=17) was perceived as important.
- Tutoring (N=16) and counseling services provided by the program (N=13) were noted by general undergraduate programs.
- Academic course work done in conjunction with the program (N=13) was a strategy listed by some respondents.
- Study groups, support groups, and student mentors (N=12) were often effective.
- Financial support for participants (N=11) was a key component, especially for graduate science/engineering programs.
- Opportunities to meet/work with role models and to take field trips to science/engineering work sites (N=10) were successful in some programs.
- Career conferences/outreach activities (N=5) were mentioned by a few respondents.

In terms of the least effective program components (or most problematic program components), at least 3 respondents mentioned the following problems:

- Career fairs and one-time outreach activities were not effective (N=18). This was most frequently noted by both undergraduate and graduate general recruiting programs.
- Lack of financial support for students and for the program create difficulties in program operation and effectiveness (N=10). This was most commonly mentioned by undergraduate and graduate science/engineering programs.
- Recruiting students for the program was difficult (N=8). This was most often noted by undergraduate science/engineering programs.
- Tutoring was not effective (N=8). Again, this was most often a problem for undergraduate science/engineering programs.
- Using traditional classroom strategies such as lecture and discussion were not effective (N=6). This was especially noted by precollege programs.
- Providing a campus residential experience for participants was costly (N=5).
- Large requirements of time from faculty members made it difficult for many faculty members to participate (N=4).
- Field trips (N=4), academic skills seminars (N=4); social activities (N=3) were not effective.
- Lack of staff training was problematic (N=3).

It is important to note that, with the exception of staff training, each of the problems cited above corresponds with one of the program strengths cited in the preceeding list. This provides additional evidence that financial support for both the program and its participants; active and effective recruitment of participants; carefully designed and implemented outreach activities; academic support (including the use of trained tutors); emphasis on hands-on laboratory work rather than lecture and discussion; providing students with a taste of campus life; and support from faculty members are all key components in effective intervention programs.

Publications

Just over a quarter (27%; N=91) of the programs responding had published materials or reports related to the project activities or evaluation. Even fewer (N=41) had developed videotapes, slide shows, or other audio-visual materials. The programs most likely to produce these types of materials were those most likely to be developed and/or supported by external grants (precollege and undergraduate science/engineering programs) or to do outreach to schools (general undergraduate programs).

Institutional Niche

Intervention programs in science and engineering often begin as a separate set of activities, funded by external sources such as a federal grant, and directed by a non-faculty member. However, their long term survival and effectiveness hinge upon the support and commitment of the host institution. Therefore, the survey asked specific questions about how the program functioned within the institution and the support it received from various institutional administrators and faculty members.

Within the institution, programs were housed in a variety of departments and offices. The largest groups of programs were in the schools/departments of engineering (22%; $N = 62$) and the schools/departments of science and technology (19%; $N = 55$). A number of programs were also housed in student affairs offices (11%; $N = 31$) and in academic affairs offices (8%; $N = 22$). In terms of specific program types, precollege and undergraduate science/engineering programs were most likely to be housed within the school/department of engineering (20% and 41%, respectively). General recruitment/retention programs for undergraduates were dispersed primarily among offices of student affairs (20%), and admissions offices (15%). Both general (71%) and science/engineering (45%) graduate programs were typically located in the graduate school. Programs for faculty members were dispersed among a variety of offices, but 25% were housed within the provost's office.

Most of the programs (56%) function as a set of discrete activities and components of the program had not been mainstreamed or institutionalized into the regular activities of the host institution. Programs specifically focusing on science or engineering were least likely to have mainstreamed activities at the precollege (31%), undergraduate (46%) or faculty levels (33%). Also, programs targeted at women (32%) were less likely than those targeted at minorities (47%) or women and minorities (52%) to have mainstreamed program components.

Respondents were asked to rate the overall support that the program had received from: (a) top institutional administrators (president/chancellor, vice-presidents, deans); (b) administrators of departments/schools with whom they work; and (c) faculty of departments/schools with whom they work.

Each of these groups received high ratings for support; "excellent" ratings were given by large percentages of program respondents to top administrators (56%), departmental administrators (48%) and faculty members (43%). There were some differences in perceived support among the program types, however. Both undergraduate ($p < .05$) and graduate ($p < .001$) science and engineering programs felt that top administrators significantly more supportive than the faculty. Similarly, general undergraduate programs perceived more support from departmental administrators than from faculty members ($p < .01$). In summary, program administrators felt that they were receiving excellent support, especially from top administrators of the institution.

Conclusions and Recommendations

1. Target Population

The results of the current study reconfirm those of Malcom (1983); few programs directly target female students or faculty. In fact, less than 10% of the programs in the current study were specifically focused on the recruitment

and retention of women in science or engineering. Programs for women were more likely to charge fees for services and to rely heavily on the use of faculty volunteers; both of these characteristics can create barriers to the longevity of a program. If the trend toward reduction of program activities for women reported by WEPAN (Daniels 1990) continues in engineering and is also occurring in areas of science where women remain underrepresented, the number of programs focusing on women will continue to decline and the number of women entering science and engineering will continue to decline, as well.

Similarly, the number of efforts targeted toward graduate students and faculty members were extremely limited in both number and diversity. Graduate efforts were primarily in the form of recruitment and/or financial support. Both of these are necessary efforts, but may not be sufficient to facilitate the persistence and success of female and minority graduate students in science and engineering departments. Faculty programs also focused heavily on recruitment, but few had any activities to support the integration of the new faculty member into the department or to promote mentoring by more experienced colleagues.

Even at the precollege level, only about half of the programs involved parents of students. Less than a third of undergraduate science/engineering programs did so. However, as described in Chapter 1, parental involvement in efforts to encourage women and minorities in science and engineering are keys to success.

Recommendations:

A rejuvenation of efforts to recruit and retain women in science and engineering is needed. Effective program models and materials are abundant but dissemination of these models must be funded, and program models, materials, and dissemination methods must be evaluated.

- Program models not only for the recruitment, but for the retention of female and minority graduate students and faculty members in science and engineering are desperately needed. These program models should be based, as much as is possible, on educational research findings, and should be implemented, extensively evaluated, revised and broadly disseminated.
- Parental involvement in efforts targeted toward students is critical, even at the undergraduate level. Programs should make efforts to help parents understand how and why students become scientists and engineers (including the training required and job opportunities available), how the program activities can assist students in reaching their goals, and how parents can assist their children in this process.
- Similarly, the role of "significant others" should be examined at the graduate and faculty level. Studies indicate that financial and emotional support (or lack of support) from spouses and/or parents can make the difference in the persistence of graduate students through degree completion. Program and/or departmental activities should be established to assist these key persons to understand the graduate education process.

2. Program Participants

The programs responding to the surveys involved large numbers of Black students, moderate numbers of Hispanic students, and limited numbers of American Indian students. Programs targeted at minorities do a good job at involving Black females in program activities, but Hispanic and American Indian females are less likely to be involved. Programs for women have not been as successful in recruiting minority females into their activities.

Recommendations:

- In general, programs must expand their recruitment efforts into new areas. Precollege and undergraduate programs must establish relationships with churches, community-based organizations such as Girl Scouts, Girls' Clubs, and Urban Leagues, and parochial schools. Graduate and faculty programs must establish ongoing partnerships with administrators and science and engineering faculty at higher education institutions that serve large proportions of minority students to develop a pipeline of minority graduates interested in their programs. In the case of faculty members, institutions may need to develop relationships with potential faculty members early—during or prior to their entrance into graduate school. In general, recruitment efforts must reach far back into the educational pipeline and promote the development of students (Farrell 1988).
- Programs targeted at women must make efforts to recruit more minority women into their programs. Outreach efforts can be made through schools, community-based organizations, and churches.
- Minority programs that include Mexican Americans, Puerto Ricans, and other Hispanics must make special efforts to increase the representation of women from these groups among their program participants. This may require special outreach programs, evaluation of how girls and parents perceive the program, and working with parents.
- In general, programs must make special efforts to recruit and retain American Indian students. This is especially critical at those institutions that serve a significant American Indian population.

3. Program Components

Intervention programs generally use a variety of strategies and activities to achieve their goals. Not all strategies and activities are equally valuable, rather, the goals of the program, the resources available, and the target group of participants should determine the particular components included in a program.

Recommendations:

- Programs that have academic components should avoid overuse of traditional teaching strategies such as lecture and discussion and focus on more effective strategies such as hands-on (laboratory),

inquiry approaches, and cooperative group work. Even programs such as one-time career fairs should include a hands-on component.

- Programs targeted at women should be structured more like those for minority students, including multi-year involvement with students, strong academic components, increased daily/weekly contact with students, and reducing the number of programs that charge fees.
- Although they are costly and staff-intensive, residential campus experiences (overnight, summer, and bridge programs) are extremely effective and should be continued and expanded. By helping students become comfortable in the campus setting, they build confidence and skills necessary for the successful transition from secondary school to collegiate work.
- The use of one-time outreach programs for generating interest in science and/or engineering should be carefully considered. Effective programs typically include activities for parents and teachers as well as for students, have a specific focus on sparking interest among female and/or minority students, and are accompanied by follow-up activities for students (such as campus visits or personal letters and/or calls from current undergraduate students).
- New models are needed for effective tutoring components in science and engineering undergraduate programs. Models such as science/mathematics/engineering learning centers, formal study groups, and student mentors need to be implemented, evaluated, revised and disseminated.

4. Program Staffing and Funding

Currently, the staff at most of the programs reflect the racial/ethnic groups and sex of the program participants. Programs that serve primarily White females have a staff primarily composed of White females. Programs targeting Black students have a large proportion of Black staff members. This role modeling effect is a positive asset in intervention programs (Malcom 1983), however, it must be balanced with the need for diversity among the staff in terms of racial/ethnic group, sex, and type of job. Since most programs have a small staff, it may be possible to use faculty and student volunteers to increase the diversity of the staff profile.

A stable funding base is critical to the continued existence of an intervention program. Some programs mainstream program activities into the regular activities of the host institution and, therefore, rely primarily on the institution as a source of support. Other programs rely on external funds. This seems to be especially true for science/engineering programs. However, the programs in this study were very likely to rely on a single funding source. Unless these programs are successful in maintaining this source of funding, their survival is at risk.

The large majority of programs find funding to support their activities either within the host institution or externally; but very few charge fees of their participants even though finding support to finance student participation is

difficult. Programs targeting women are the exception; they are more likely than other program types to charge fees of their participants. This was true in Malcom's (1983) study, as well.

Several contact persons indicated that providing financial support for students was a key element in the success of their programs. This is especially true for programs serving graduate students. However, there are potential pitfalls in providing graduate fellowships specifically for women or minorities. Many of these fellowships support a student only for the first year or two of graduate work. Often these students are seen as *peripheral* members of the department; they do not receive continued support through institution-sponsored assistantships or tuition waivers and never find a research niche—a laboratory in which to work and a mentor to guide them.

Recommendations:

- The racial/ethnic group, sex, and job responsibilities of the program staff should provide role models for not only the current program participants but for those the program hopes to attract, as well. For example, programs targeted at women should include persons of diverse racial/ethnic groups as administrators, support staff, and program volunteers.
- Programs should develop a stable funding base either by mainstreaming program components into the overall activities of the host institution and, therefore, becoming a regular budget item for the institution or by developing a diverse group of external funding sources.
- Programs should continue to avoid participant fees whenever possible, and funding should be provided by the institution to assure that financial need does not prevent participation in programs by women and minorities.
- Programs serving women should be examined to determine why they are more likely to charge fees; these programs should avoid fees to insure a diverse group of participants.
- Programs which provide fellowships for female and/or minority graduate students should be sure that there are mechanisms in place at the institution to promote departmental commitment to the student's success and continued support.

5. Evaluation

Only half of the programs in this study have completed even a general evaluation of their program's effectiveness. Yet evaluation is a basic component of program development and implementation. As funding budgets become increasingly tight, program directors will be asked to provide more than a rudimentary head count of the number of participants in the program. They will be asked for evidence that the program meets long-term as well as short-term goals: Are attitudes, motivation, skills, specific behaviors, and goals changed by the program? Which program activities are most effective? Which are cost effective? Is the program serving the target population? Do women and minorities have open access to the program? What is the long-term impact

of the program, that is, does it really promote interest, participation, and/or achievement in science, mathematics, and/or engineering? How do you know? These are the types of questions which governmental agencies and private foundations are beginning to ask program directors. Without adequate evaluation, many programs will find fund raising a difficult endeavor.

Recommendations:

- Evaluation must be a integral component of intervention programs, not an *add-on* at the program's completion. Specific program goals should be set and evaluation methods designed to assess those goals.
- Program staff should utilize evaluation consultants as needed to assist in design, implementation, and analysis of the evaluation. However, it is imperative that the evaluation not be *turned over* to an outside consultant – the program staff must be involved in each aspect of the evaluation in order to make it a productive effort.
- Funding agencies and institutional administrators should require program directors to provide evidence that specific program goals have been set, a detailed plan of evaluation has been constructed, and a regular method for reporting evaluation results has been established. However, funders also should provide training for program directors on developing and implementing program evaluation and, subsequently, the funds necessary to conduct a good evaluation and the time needed to measure results over a reasonable period of time (preferably over a number of years).

6. Institutional Relations

The programs and services listed by presidents and chancellors of the 276 institutions participating in the study were, in most cases, only a sample of the science/engineering programs in operation at each institution. For many colleges and universities, AAAS staff were aware of additional programs and efforts. At other institutions, the contact persons provided information about additional programs and services on their campus which were not listed by their president or chancellor. In general, there did not seem to be a central source of information or coordinated effort concerning recruitment and retention of women and/or minorities in science or engineering (see Chapter 5 and 6 for additional discussion of these issues).

Most program staff felt that they had strong support from top administrators and departmental administrators. Perceived support from faculty members was somewhat lower. This may reflect the difficulties some program staff have encountered in recruiting faculty members to participate in program activities. While one-on-one interaction with faculty members was cited as one of the most successful strategies used in many programs, it is also perceived as very time consuming for both faculty and program staff. Participation in intervention programs can create special problems for science/engineering faculty members, especially those who are female and/or minority.

In many departments, especially those at research universities, active participation in an intervention program or other student-focused activity, is encouraged among faculty members but does not count significantly in the

tenuring process. Therefore, faculty members must choose to take time away from research and funding activities to participate in program activities which may or may not assist in their efforts to receive tenure in the department. This is especially true for female and/or minority faculty who are not only working toward tenure, but are often asked to serve as the sole female or minority on institutional committees and also may feel considerable personal and professional pressure to participate in intervention programs where they are desperately needed as role models. Female faculty members may be especially susceptible to this type of pressure, since programs targeted at women rely heavily on the use of faculty volunteers.

Recommendations:

- Science and engineering recruitment/retention programs should not be isolated efforts on a campus. Rather, some coordination or, at minimum, regular communication should occur among programs. Programs specific to life sciences, chemistry, physics and engineering share some common goals, common program activities, and common problems. By sharing strategies and coordinating some activities, separate programs might be able to function more cost-effectively and, therefore, to expand program activities and services.
- Faculty involvement in intervention programs is critical to their success (Clewell and Ficklen 1986); therefore, involvement should be encouraged. However, it must also be rewarded. Participation in program activities should be counted in the tenure process along with research productivity and teaching. Similarly, female and minority faculty members should not be pressured to overload their schedule with committees and programs, but should be allowed and encouraged to balance research, teaching, and intervention activities while minimizing committee involvements in their first years.

Table 3.1 Target Group for Intervention Programs by Program Type

Program Type	Percentage (number) of Programs Targeted at			
	Minorities ¹	Women ²	Minorities and Women ³	Others
Precollege (K-12)	50% (34)	12% (8)	35% (24)	3% (2)
Undergraduate General	50% (38)	5% (4)	22% (17)	22% (17)
Undergraduate S/E	58% (38)	10% (12)	25% (29)	7% (8)
Graduate General	50% (5)	0% (0)	50% (5)	0% (0)
Graduate S/E	52% (12)	4% (1)	26% (6)	17% (4)
Faculty	25% (5)	20% (4)	35% (7)	20% (4)
Total	51% (160)	9% (29)	28% (88)	11% (35)

Note: $\chi^2 = 31.78$, $df = 15$, $p < .01$.

¹ Includes programs targeted at "minorities only" and "all" students with special efforts for minorities.

² Includes programs targeted at "women only" and "all" students with special efforts for women.

³ Includes programs targeted at "minorities and women" and "all" students with special efforts for minorities and women.

Table 3.2 Average Percentage of Program Participants by Racial/Ethnic Group and Program Target Group

Program Target Group	Average Percent (Standard Deviation)				
	American Indian	Black ¹	Total Hispanic	White ²	Other ³
Women only	1% (.040)	7% (.117)	8% (.134)	70% (.301)	14% (.192)
Minorities only	9% (.237)	58% (.365)	19% (.236)	8% (.219)	6% (.144)
Women and Minorities	2% (.086)	40% (.354)	14% (.183)	33% (.345)	12% (.188)
Other	5% (.176)	32% (.317)	13% (.216)	44% (.361)	6% (.080)
Total	6% (.190)	47% (.374)	15% (.210)	23% (.335)	8% (.159)

¹ $F = 16.24$; $df = 273$; $p < .0001$.² $F = 38.71$; $df = 273$; $p < .0001$.³ $F = 3.41$; $df = 273$; $p < .05$.

Table 3.3 Average Percentage of Program Participants who are Female by Program Target Group and Participant Racial/Ethnic Groups

Program Target Group	Average Percentage of Female Participants (Number of Programs Responding)					
	Total ¹	American Indian ²	Black ³	Mexican American ⁴	Puerto Rican ⁵	Other Hispanic
Women Only	86% (22)	87% (5)	87% (18)	100% (6)	100% (3)	68% (9)
Minorities Only	51% (138)	38% (54)	53% (124)	43% (39)	38% (24)	44% (56)
Women and Minorities	56% (73)	38% (38)	62% (65)	53% (20)	45% (8)	42% (28)
Other	51% (22)	48% (9)	49% (19)	40% (6)	63% (4)	43% (9)
						74% (19)
						58% (26)
						64% (46)
						49% (20)
						73% (13)
						42% (38)
						55% (35)
						49% (13)

¹ $F = 17.59$; $df = 254$; $p < .0001$.

² $F = 3.57$; $df = 89$; $p < .05$.

³ $F = 12.88$; $df = 225$; $p < .0001$.

⁴ $F = 7.97$; $df = 70$; $p = .0001$.

⁵ $F = 3.75$; $df = 38$; $p < .05$.

⁶ $F = 3.22$; $df = 98$; $p < .05$.

Table 3.4 Frequency of Contact with Program Participants, by Program Type

Program Type	Percentage (number) of Programs				
	Daily	> 1 Time Per Week	> 1 Time Per Month	< 1 Time Per Month	Other ¹
Precollege (K-12)	43% (29)	21% (14)	9% (6)	2% (1)	26% (18)
Undergraduate General	20% (15)	27% (20)	18% (13)	6% (4)	29% (21)
Undergraduate S/E	45% (52)	14% (16)	14% (16)	5% (6)	22% (25)
Graduate General	38% (3)	0% (0)	0% (0)	0% (0)	62% (5)
Graduate S/E	27% (6)	9% (2)	14% (3)	0% (0)	50% (11)
Faculty	18% (3)	0% (0)	24% (4)	0% (0)	59% (10)
Total	36% (108)	17% (52)	14% (42)	4% (11)	30% (90)

Note: $X^2 = 43.20$; $df = 20$; $p < .05$.

¹Primarily "as needed"

Table 3.5 Proportion of Female and Minority Employees, by Program Target Group

Program Target Group	Average Proportion of Women or Minorities (Standard deviation)			
	Minority: Full-Time ¹	Minority: Part-Time ²	Women: Full-Time ³	Women: Part-Time
Women	.15 (.376)	.15 (.337)	.88 (.300)	.85 (.337)
Minority	.57 (.380)	.48 (.422)	.62 (.343)	.55 (.365)
Women/ Minority	.40 (.398)	.32 (.369)	.68 (.336)	.62 (.346)
Other	.44 (.426)	.28 (.359)	.74 (.284)	.58 (.352)
Total	.49 (.404)	.39 (.406)	.67 (.337)	.59 (.361)

¹ $F = 6.28$; $df = 218$; $p < .001$.

² $F = 4.14$; $df = 186$; $p < .01$.

³ $F = 2.29$; $df = 200$; $p < .05$.

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Science and Engineering Students with Physical Disabilities: Who Smooths the Path?



Marsha Lakes Matyas and Virginia W. Stern

The pathway to a degree in higher education is seldom perfectly straight and smooth for any student. Simply learning how to negotiate the processes of admission, registration, and housing services provides significant challenges for all entering students. However, students with physical disabilities have a considerably more winding and bumpy path to follow. In addition to the routine considerations, they must consider the availability of physical access to campus and classrooms, services and equipment available which will allow their full participation in their courses, and the overall attitude of the faculty, administration, and student body toward students with physical disabilities.

Once the student with a disability has matriculated, his or her requests for support services are frequently handled by a campus-wide disabled student services office (DSS). At some institutions, the functions of a DSS are distributed among several campus offices. A DSS might provide services such as: oral or sign interpreters; lecture tapes, note-takers, and assistive listening devices; accessible buses or other campus transportation; and laboratory assistants. Some DSSs work more as coordinating agencies rather than actual providers of services (Scales 1991). For example, a DSS might arrange for a librarian to be trained to assist students with disabilities rather than having a DSS staff member assist the student in the library. The DSS also might work with the university career service office to sensitize them and equip them to be responsive to the needs of students with disabilities. This allows students with disabilities to become less dependent upon special services and more fully integrated into the regular programs of the college or university—the ultimate goal of all DSSs.

Traditionally, students with physical disabilities who earn degrees in higher education are unlikely to concentrate their studies in science or engineering. The reasons for this are complex, depending not only upon the traditional variables that influence all students (such as interest, achievement, and prior experiences) but also upon the type of disability, the timing of the onset of the disability, the student's interaction (or lack thereof) with

science/engineering role models with disabilities, and the facilities and "climate" at the particular higher education institution. Once a student with a disability decides to major in science or engineering, what additional obstacles will be encountered? How do DSSs assist these students? To explore these questions, this study examined how the needs of students with physical disabilities who are majoring in science or engineering are met. Unlike programs targeted at women and minorities, it is extremely rare to find a program on campus which specifically targets students with physical disabilities in science or engineering majors.

A specific survey was sent to DSSs at colleges and universities participating in the overall study. The survey requested general information about the function of the DSS and the population it serves. For the purposes of this survey, students with physical disabilities were defined as "those who have one or more of the following: blindness or severe visual impairment, hearing and/or speech impairment, mobility impairment, or chronic health problems." Information was also requested about how the DSS would handle three hypothetical situations involving students with specific physical disabilities: (1) a hearing-impaired student in engineering requesting oral interpreters for large lecture courses; (2) a mobility-impaired student requesting a laboratory assistant for a chemistry course; and (3) a visually impaired student requesting specific technology and services for a calculus course.

Responses to the survey provided insights into the successes and difficulties faced by both students with disabilities and by the offices established to assist them.

Disabled Student Services Offices

The American Council on Education (ACE 1989) summarized the implications of Section 504 of the Rehabilitation Act of 1973 in the following way:

Section 504 of the Rehabilitation Act of 1973...prohibits discrimination in those postsecondary education, training and employment programs that receive Federal funds. Section 504 provides that 'no otherwise qualified handicapped individual...shall, solely by reason of a handicap, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance.' According to the Regulations, a 'qualified' individual with handicaps, with respect to postsecondary and vocational education, is defined as one 'who meets the academic and technical standard requisite to admission or participation in the recipient's education program or activity'...Section 504 prohibits discrimination against persons with disabilities by institutions who are recipients of Federal funds. This applies to recruitment, testing, admissions, and treatment after admission. Therefore, colleges, universities, and other postsecondary institutions are required to make reasonable adjustments and change discriminatory policies so that qualified students with disabilities can fulfill academic requirements. Students are not to be excluded from programs because of physical barriers or the absence of auxiliary aids (P. 24).

The 504 regulations do not specify a single, acceptable method for higher education institutions to offer these services to students with disabilities. Most institutions do so through a disabled student services office (DSS). According to data from the initial survey of presidents/chancellors, 74% of institutions participating in this study have a DSS. Research Universities (92%), Doctorate-Granting Institutions (81%), and Comprehensive Colleges and Universities (81%) were most likely to have a disabled student services office or coordinator of services for disabled students. Liberal Arts Colleges (28%) and Professional/Other Institutions (44%) were least likely to offer these services through a specific office or coordinator. Some institutions distribute these duties among a number of campus offices.

Although 74% of the 276 colleges and universities participating in this study indicated that they had some type of disabled student assistance office, only 92 institutions (45%) completed and returned surveys. Response rates were similar for each of the five Carnegie groups of institutions (see Figure 2.1 pg. 39, for description of types).

Most of the DSSs (70%) had been in operation for 6 to 15 years, indicating that they probably were initiated in response to the 504 regulations. Nearly half (43%) functioned on total yearly budgets of less than \$100,000 and 13% operated on less than \$25,000 per year. Very few of these programs (3%), however, charged students a fee to enroll for services; this does not imply, however, that students were not expected to pay for some of the services they received. Information on the funding of these programs for the most recent year indicates that over half (56%) of the DSSs received at least 75% of their funds from the college or university. Nearly one third of DSSs received the bulk of their reported funding from state or federal agencies to support services for students. Business/industry and private foundations were not significant sources of funds for most DSSs, although some equipment, such as Kurzweil reading machines, were often donated by manufacturers or foundations.

The survey also examined staffing patterns for the DSSs. In general, the DSSs had limited staff. Over a third of the DSSs responding had no full-time employees and over half employed between one and three part-time employees. (Table 4.1). On average, the responding DSSs had 2.4 full-time and 2.0 part-time regular employees. Employees at the DSSs responding to this survey were rarely physically disabled themselves, however. Only 18% of the responding DSSs employed a full-time staff member with a physical disability and only 22% employed a part-time staff member with a physical disability.

A number of DSSs also employed students, typically on a part-time basis. In fact, five of the institutions surveyed employed between 60 and 90 students on a part-time basis; students often serve as office workers, personal care attendants, oral or sign interpreters, lab assistants, or note-takers. The DSSs also had student and faculty volunteers who worked with their offices (Table 4.2), although faculty volunteer programs (found at 26% of the DDSs responding) were much rarer than were volunteer programs involving students (found at 50% of the DSSs). In general, the DSSs appeared to make use of limited paid staff and to utilize student volunteer or part-time employment programs.

The survey also asked DSS directors about the support they received from administration and faculty. For the most part, DSS directors felt they received excellent support from top institutional administrators, from administrators of the departments and schools with whom they worked, and from faculty of departments and schools with whom they worked.

Who is Served by DSSs?

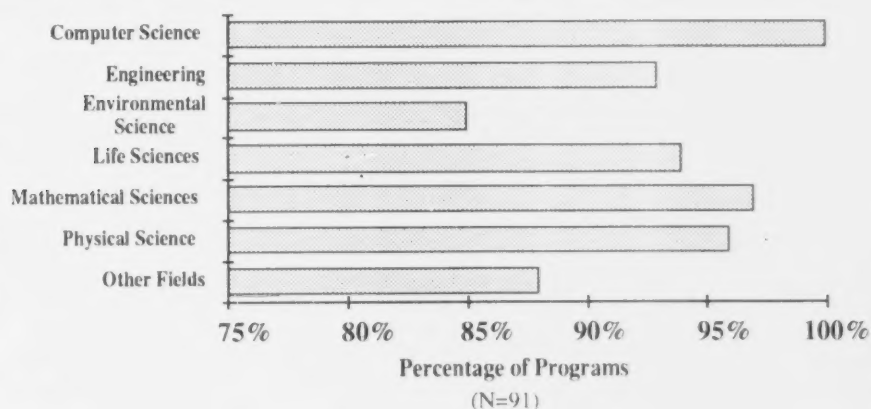
The large majority (84%) of the DSSs responding to the survey served both students with physical disabilities and those with learning disabilities. When asked to break out the number of students served by physical disability versus learning disability, only two-thirds of the DSSs did so. Among the offices that provided this information, over half of the students served were physically disabled, while less than a third were learning disabled. The remaining students either had both physical and learning disabilities or had unidentified disabilities. These findings are similar to those of the National Center for Education Statistics (NSF 1990) which found that most students reported physical disabilities and only 12% reported having learning disabilities. This profile of students with disabilities who request assistance from a DSS, however, may be changing. At the University of Maryland, the number of learning disabled students requesting services from the DSS has increased from zero in 1980 to 150 in 1991 (Scales 1991). As the number of students with learning disabilities who enter colleges and universities increases, the number and type of services requested from DSS staff may increase as well.

The DSSs were most likely to directly target undergraduate (98% of DSSs) and graduate (81%) students as participants in their services and rarely worked with students in elementary (1%), middle school (1%), or secondary school (4%). Most (64%) did not work specifically with faculty members. This undoubtedly reflects the primary mission of these offices to serve students enrolled at the institution rather than to act as a recruiting or referral service.

DSS staff do not necessarily interact with all students with disabilities on campus. The student decides whether or not to contact the DSS and request assistance. According to responses to the survey, DSSs (40%) tended to work with students primarily on an *as needed* basis rather than at least once per week (28%) or once or twice a month (24%). They also tended to work directly with the student rather than working with faculty. DSSs rarely worked with parents. In fact, less than a third (26%) of the DSSs had any program activities that involved the parents of their students.

Most of the DSSs responding worked with students in a variety of majors; the large majority worked with students in most science and engineering fields (Figure 4.1). However, the majority of students served by the DSSs are non-science majors (70%). Only 16% of all students served were science or engineering majors and only 14% of students served with physical disabilities were in science or engineering majors. Therefore, DSS staff may have had fewer opportunities to develop working relationships with science and engineering faculty members compared to non-science/engineering faculty members. Also, since students with disabilities are rarely found in science or engineering departments, faculty members in those departments have limited opportunities to learn how to assess and fulfill the needs of these students.

Figure 4.1 Major Fields of Study Included in Disabled Student Service Programs



Support Services for Science-Related Studies

Students with physical disabilities must negotiate a variety of barriers to complete their undergraduate or graduate studies. Depending upon their particular disability, physical barriers may be reduced by following certain recommendations.

1. Provide parking within reasonable distance of buildings and accessible public or campus transportation within reasonable distance of buildings
2. Make buildings accessible via curb cuts, ramps, automatic doors, and elevators with Braille or audio floor indicators and call buttons
3. Improve access to classrooms and administrative and faculty offices via elevators, ramps, and doorways of appropriate size

The following additional support services can facilitate academic success and persistence among students with disabilities.

- Oral or sign language interpreters for hearing-impaired students
- Note-takers, readers, and classroom audiotapes
- Access to faculty members' lecture notes in print or alternate modes
- Textbooks recorded on audiotape
- Assistive listening devices
- Accessible electronic equipment such as computers
- Extended time for exams
- Tutors

- Rescheduling of classes in an accessible building if the existing building cannot be made accessible in time for the student to take the class
- Working relationships with professors and graduate teaching assistants
- Adaptive technology to complete course writing assignments and
- Access to other campus services such as career and placement services whose staffs have been trained to make appropriate arrangements for students with disabilities

For students with physical disabilities who major in science or engineering fields, some additional barriers may be encountered. First, although a classroom building may be generally accessible to mobility-impaired students, the laboratory classrooms may be inaccessible due to lack of elevators or size of door openings. Further, most laboratory classrooms do not have benches built to accommodate students with certain disabilities.

Second, the equipment used in laboratory work may need adaptation for use by students with specific disabilities. For example, hearing-impaired students may need to have instruments with visual readouts rather than auditory signals. This can be especially important for laboratory safety devices. Visually impaired students may need to use instrumentation with auditory rather than visual readouts and may need access to three-dimensional models to visualize events such as cell-division or magnetic fields. Mobility-impaired students may need a variety of modifications made so that they can utilize laboratory equipment.

The general rule in laboratory settings should be that, whenever possible, the student should do as much of the "hands-on" work as his or her disability will allow. *Watching* or *listening* while someone else performs the laboratory work does not have the same value as *doing*. When a particular disability prevents the student from doing the laboratory work alone, a partner may be utilized. However, the student with the disability should continue to be actively involved in making decisions concerning methods, observing and recording results, manipulating raw data via calculation, and drawing conclusions.

A third consideration for students with physical disabilities is acquiring usable classroom notes and textbooks. Ideally, the note-taker should be someone familiar with the content area or, at least, at the same level of study in the content area as the student with the physical disability. Often, a fellow student in the class is called upon for this service. Acquiring audiotaped or Braille textbooks for science, mathematics, or engineering courses is a larger challenge for two reasons: (1) many texts in these fields become quickly outdated, therefore, every year there is a new "standard" text in the field; and (2) recording these texts and translating equations, figures and graphics into audio or Braille descriptions requires skills in both the specific content area and in this specific type of translation.

Many visually impaired students turn to the free services of Recording for the Blind, Inc. (RFB) for audio cassettes of their textbooks. Unfortunately, RFB has had considerable difficulties in being able to provide current science/mathematics/engineering textbooks for the reasons cited above. In 1987, RFB and the AAAS Directorate for Education and Human Resources Programs launched a joint effort to recruit 1,000 scientists and engineers in 32 cities to volunteer time to learn how to record texts in their content area and to actually record textbooks for students. To date, the project has been successful, recruiting 600 new volunteers with technical backgrounds. Another promising

option for visually impaired students is the production of computerized texts, especially computer manuals, which can be obtained directly from the publisher. These computerized texts can be converted to both voice output and Braille.

The fourth barrier science and engineering students with physical disabilities often face is forging a working relationship with science and engineering faculty members and graduate teaching assistants. Since few students with physical disabilities major in science or engineering fields, most science/engineering faculty have had few, if any, students with disabilities in their classrooms. Consequently, faculty have had little or no experience or training in dealing with the support services needed by students with disabilities. In most cases, it becomes the student's responsibility to approach the faculty member, explain the nature of his or her disability, and suggest the adaptations needed for the course. This assumes, however, that the student already knows the course and laboratory content — which is rarely the case.

Finally, science, mathematics, and engineering courses increasingly utilize personal and main frame computers and specialized software. It is important that appropriate hardware and software be available so that students with various disabilities can access the keyboards and effectively utilize the course software. For example, visually impaired students may need additional software and hardware to allow information generated by course-specific software to be accessed via synthetic speech output or refreshable Braille.

Case Studies in Science and Engineering: DSS Responses

Since students with physical disabilities who major in science or engineering are rare, DSSs may not have had opportunities to learn to deal with some of the specific support services that these students need. The current survey presented each DSS with three hypothetical situations describing the assistance that might be required by a student with a specific physical disability who is majoring in science or engineering. These situations were ones previously encountered by staff of the AAAS Project on Science, Technology, and Disability. DSSs provided details on how they would handle each type of situation.

A Hearing-Impaired Student

An academically talented, profoundly deaf student has been admitted to the entering freshman class in engineering. The student has been mainstreamed in regular school during the precollege years. She lip-reads and speaks, but does not use sign language. In high school, she did not use interpreters in the classroom, but she feels she needs interpreters for large college lectures and seminars. She requests oral interpreters. How would you arrange for this service? Who would pay for the service? If the service were not readily available, from whom in the academic or outside community would you request information? What technology or other assistance would you provide? How often have you encountered a situation similar to this one?

Less than half of DSSs responding (43%) indicated that they encountered this type of situation "frequently" or "sometimes" (Table 4.3). Most DSSs (74%) said they would be responsible for locating and contracting with oral interpreters for this student. However, 13% of the DSSs said they would

depend upon the state vocational rehabilitation agency to make these arrangements for the student. Seven DSSs (8%) said they would be unable to provide this type of service at all. One DSS director stated that his/her office would arrange this service "...with great difficulty. General availability [of oral interpreters] is almost nil. Then, availability at the required time is a further complication. Our previous referral agency no longer cooperates with educational requests. The only hope would be plenty of lead time and a miracle (which often happens in these tough cases!)."

DSSs were asked to list who they contacted when confronted with an unusual situation or lack of resources; they listed a variety of information sources:

- State vocational rehabilitation agency (SVR) (46% would contact)
- Local community agencies (42%)
- Other colleges and universities (29%)
- National organizations (8%)
- Other state agencies (8%)

DSSs were much more likely to call upon state and local community agencies or other colleges and universities, especially those in the same geographic region, than to call national organizations such as AAAS, HEATH, or the Association of Handicapped Student Services Programs in Post-secondary Education (AHSSPPE). This may reflect the need for names of local interpreters and funds to pay the interpreters in this particular situation.

The DSSs surveyed also indicated that they would provide additional technology and assistance for this hypothetical deaf student, as appropriate:

- Note-taker (56% would provide)
- Tutor (24%)
- Assistive listening device such as Phonic Ear or FM (12%)
- Lecture tapes for transcription (10%)
- Computer (9%)
- Testing accommodations (7%)
- Continued interaction between DSS staff and the course professor (6%)

A Mobility-Impaired Student

A newly enrolled junior is signed up for a laboratory course in analytical chemistry. He attended another university for his first two years. During the summer after his sophomore year, he was in an automobile accident and is now quadriplegic. He uses an electric wheelchair and has only partial use of his arms and hands. He requests a lab assistant to assist because he cannot easily handle the laboratory equipment. The course professor has not had previous experience with a student with a disability. What accommodations would you provide? When would you speak with the professor and what would be his or her role? Where would you go to

seek further information? How costly are the accommodations and who would pay for them? How often have you encountered a situation similar to this one?

Nearly half (46%) of the DSSs had encountered this type of situation "frequently" or "sometimes" (Table 4.3). The large majority (81%) of the DSSs would contact the professor as early as possible before the course begins. The remaining 19% preferred to have the student handle this situation and would contact the professor directly only if the student requested it or if a problem developed.

Similar to the student described in Situation 1, the DSSs would provide a variety of services for this student:

- Lab assistant (87%)
- Accessible laboratory and/or special equipment (30%)
- Note-taker (16%)
- Test accommodations (10%)
- Continued work with the professor (9%)

A number of DSSs indicated they would specifically work with the professor to help him or her understand how to work with a mobility-impaired student and to work as a team to make sure the laboratory was accessible to the student.

A Visually Impaired Student

A blind student is registered for a course sequence in calculus. She needs to have the textbooks on cassettes and a computer with voice output that also converts to Braille. She also needs reader services for the weekly problem sets and other course materials distributed by the professor. She makes her requests for fall before she leaves for the summer. How would you handle this request? Which of the required pieces of equipment are available on your campus? How would you obtain equipment that you do not have available at this time? Who would record the textbooks? Who would pay for each of these services? How often have you encountered a situation similar to this one?

This situation was the one most commonly encountered by the DSSs; nearly 70% said they had encountered similar situations "frequently" or "sometimes" (Table 4.3). The written responses also suggested this was not an uncommon situation. When asked about how they would handle the student's needs, many respondents listed the steps, "1, 2, 3,..." suggesting a set routine. This was in contrast to responses to Situation 2, described above, where respondents were more likely to say, "We could try this..."

There was some disagreement among the DSS respondents on how much lead time they needed to work on the student's requests. According to the survey question, the student "...makes her requests for fall before she leaves for the summer." One respondent noted, "We would attempt to have her/his texts taped although we request more lead time than the amount indicated here." Other respondents felt the lead time was more than adequate: "I would

be surprised the student is requesting accommodations so early," was one reply. "I would be absolutely delighted that she has made the request so far in advance," noted another respondent.

The request for recorded textbooks seemed to be a fairly routine task for the DSS respondents. Most (67%) said they would first try to assist the student in obtaining the texts through Recording for the Blind, Inc. (RFB). If the texts were unavailable through this agency, then the DSS would call upon the following resources to record the mathematics textbooks: (a) their own staff, work study students, or students in the mathematics department (45%); (b) local volunteers (24%); (c) other local/regional agencies such as Library for the Blind (20%); or (d) state vocational rehabilitation agency (13%).

Some DSS personnel noted that the technical nature of the textbooks (in this case, calculus) could create special problems:

"I would check to see what texts were required for this course. If RFB, Inc. did not already have the texts on tape, I would borrow two of each book required, and send them to RFB to be recorded. Although we have a volunteer taping service on campus, I would have highly technical materials recorded by RFB."

"If the text is available from RFB, it would be ordered. If the book was not available, we would recommend to the student that she try to have it recorded by RFB since we do not generally have the expertise to do a good job in such a technical area."

"First, it would be necessary to order and obtain from Recording for the Blind all books on audiotape, if possible. Second, arrangements must be made for work-study or voluntary readers to record those books not available. These could require contacting the department chairperson for a reader since many courses and textbooks are so technical that only those schooled in the area can verbalize it."

These comments reconfirm the need for greater availability of technical texts in Braille and on audiotape and for greater involvement of scientists and engineers as volunteers for RFB.

The computer equipment requested by the student proved to be a larger problem for the DSSs. Only 25% of the respondents said they already had the facilities to provide both reader services for weekly problem sets and access to a computer with voice output that also converts to Braille. Most of the DSSs could provide reader service (70%), and 60% had access to a computer with voice output. However, only 29% could link the computer to a Braille output. A number of DSSs pointed out that, although they did not have all of the requested equipment, they could provide cassette recorders (45%) and/or a Kurzweil reading machine (14%). Since the initial date of this survey, alternative optical character recognition devices have been developed and are rapidly becoming more available and more affordable. Undoubtedly, these devices will become available to many students through DSS services in the coming years.

The survey also asked DSS respondents how they would obtain requested equipment that they did not already have. Most indicated that they would purchase (63%) or borrow/lease (25%) the equipment. Nearly half (45%) said they would have to do some external (that is, outside the college/university) fund raising to get the necessary funds or the equipment itself. A number of

respondents noted that they might be equally successful at helping the student convince an outside agency (such as the state vocational rehabilitation agency) to purchase the equipment for her personal use.

Who Pays?

Some accommodations for students with physical disabilities majoring in science or engineering require little or no funds; often a fellow student in the class is willing to act as a note-taker, utilizing special double-copy paper or making a quick trip to the photocopier after class with the disabled student. A lab assistant is often one's regular lab partner. However, this is not always the case. Special services such as oral or sign language interpreters, laboratory modifications, and computers with special functions such as voice output and Braille conversion require specific funds. Federal legislation places the responsibility for providing these services on the institutions of higher education. These institutions may sometimes be able to accomplish this by assisting students to pursue financial aid as a client of the state vocational rehabilitation agency, or by applying to charitable organizations for assistance.

In dealing with the hearing-impaired student needing oral interpreters (situation 1), over half of the DSSs expected the state vocational rehabilitation agency to pick up some or all of the cost of the oral interpreters (Table 4.4). Four institutions expected the student to pay for some of the costs, and three institutions said the student would have to carry the entire cost.

When describing how they would arrange a laboratory assistant for a mobility-impaired student (situation 2), many DSSs said they would be able to arrange for an assistant on a volunteer basis. However, when costs would be incurred, the DSSs were more likely in this situation than in the one above to say that the college/university would pay for the cost of the accommodations, especially if laboratory modifications were planned.

In Situation 3, a blind student expresses needs for both services and specific technology. Some DSS respondents (20%) said they would rely entirely on volunteer services (such as RFB) in assisting this student. Many of these offices already had the requested computer equipment available on campus. Most respondents felt that the state vocational rehabilitation agency would pay for part of the costs of the reader services. However, many (40%) indicated that the university alone would pay, especially for purchase of permanent equipment. A small proportion (9%) said the student would be primarily responsible for the costs of reader services and computer equipment.

Throughout the survey responses to these hypothetical situations, it was clear that most DSS staff would make every effort to provide the services needed by the student and to locate funding to pay for the services. However, in many cases a sense of helplessness and hopelessness was apparent. In some cases, it was a lack of adequate funds (both internal and external) to pay for all of the student services and equipment needed. In others, it was a lack of trained personnel, such as interpreters, in the geographic area of the institution. In many cases, the respondents indicated that they simply could not provide all the services and equipment requested and had strong doubts that appropriate funds and equipment could be found. A number of respondents said it would be up to the student to come up with at least part of the funds or equipment.

When faced with a diverse group of requests for student services and equipment, DSSs often have to find ways to optimize use of limited funds and personnel. For example, students may be encouraged to enroll in courses

where an interpreter has already been assigned for the coming semester or quarter. The student may find it easier to major in areas where a number of students with their type of disability are already enrolled simply because it is easier to get access to interpreters, lecture notes or tapes, and other services or because the professors in these fields are already familiar with the staff and services of the DSS. Ultimately, students who want to enroll in courses that are atypical for students with disabilities (such as science or engineering courses) may find that they are waiting a semester or quarter until interpreters are available or until equipment is ready. With the sequential nature of many science and engineering curricula, this waiting game becomes not only frustrating, but costly for the student. The efforts of the DSS to serve as many students as possible utilizing limited staff and funds can unintentionally play a "gatekeeper" function, steering students with physical disabilities away from non-traditional majors such as science and engineering (NSF 1990).

Access to Science/Engineering Programs for Women and Minorities

Since programs specifically focused on increasing the participation of students with physical disabilities in science or engineering majors are so rare, information was sought from directors of programs for women and minorities about the participation of people with physical disabilities in their programs (see Chapter 3). The large majority (75%) of programs for female and minority students in science/engineering did not currently have any participants with physical disabilities. In fact, between 59% and 75% of responding programs for women and minorities in science/engineering have never had a student with a physical disability as a participant (Table 4.5).

However, when asked whether they could locate accommodations and technical assistance for students with physical disabilities who would be interested in participating in their program, 66-77% of the program staff members indicated that they would make the necessary arrangements. Therefore, it appears that science/engineering programs for women and minorities do not formally exclude students with physical disabilities. Rather, it seems that students with physical disabilities are not specifically recruited for these programs, do not see other students with disabilities participating in these programs, and, consequently, do not apply for admission.

Summary and Recommendations

For students with physical disabilities, there is rarely a specific program focused on removing barriers and smoothing their path to a career in science or engineering. These students are unlikely to encounter a science or engineering role model in junior high or senior high school, and there is seldom a career fair for students with physical disabilities. Unlike female and minority students, colleges and universities do not have science/engineering recruitment programs targeted at students with physical disabilities. For these students, the disabled student services office (DSS) is the primary source of help.

Students are more likely to find a full-scale, centralized disabled student services office at a Research University, Doctorate-Granting Institution, or Comprehensive College or University than at a Liberal Arts College or Professional College/University. Smaller institutions such as Liberal Arts Colleges often distribute DSS functions among several campus offices. This study does

not distinguish between the quality of one method versus another; each has its advantages and disadvantages. While these offices are responsible for serving the needs of students with physical and learning disabilities in a wide variety of major fields of study, they often operate on low budgets and with limited paid staff.

In general, these offices do not do any outreach activities to K-12 students or parents. They focus on their mission of serving registered undergraduate and graduate students, faculty, and staff at their institutions who request assistance.

Students with physical disabilities who major in science or engineering may find that the DSS at their institution has not encountered their specific needs before, especially in laboratory courses or when specific technologies or services are required. In general, the offices are willing to try to accommodate each student's needs but, in many cases, the student will have to put forth considerable effort to prepare the classroom, the professor, and the needed equipment or modifications before entry into the specific course. In some cases, the student is financially responsible for these accommodations as well. For all students, personal attention, mentoring, and nurturing the development of self-esteem are important factors in the student's success in higher education and beyond. For students with physical disabilities, the presence or absence of these factors through DSS offices, within their academic departments, and in on-campus housing can be critical in their success.

In 1990, the Americans with Disabilities Act (ADA) was passed. According to some, it is the "most important civil rights law passed in 25 years" (*New Directions* 1990). In summary, the ADA states that:

- No business with 15 or more workers may discriminate against a qualified individual with a disability
- New buses, trains and subway cars will be accessible to persons with disabilities
- Public accommodations such as new hotels, retail stores and restaurants will be accessible and architectural barriers in existing buildings will have to be removed
- Telephone companies will have to provide relay services to allow hearing or speech impaired persons with TDD's to place and receive calls from ordinary phones (*New Directions* 1990, 1)

The DSSs at U. S. colleges and universities will face new challenges in meeting the requirements outlined by this act. It is not known whether the new regulations will catalyze additional funds to become available to DSSs or whether it will further tax their limited staff and resources. In either case, the information provided by this study indicates that the specific needs of science and engineering students with physical disabilities require additional attention from administrators and faculty as well as from DSS staff. Specific recommendations include the following:

- Science and engineering departments and staff of DSS offices must make a clear commitment to providing students with physical disabilities full access to training in these fields. This requires that both the department in which the student is enrolled and the DSS take an active role in determining that a lack of needed equipment, interpreters or other services will not act as a functional

gatekeeper, preventing the student from making normal progress toward his/her educational goals. Departments (or institutions in a geographic area) may be able to generate a pool of adapted equipment available for check-out or rental during semesters when it is needed.

- Science and engineering faculty and graduate teaching assistants need to have some understanding of the rights and potential needs of students with physical disabilities who may be enrolling in their courses. The best time for this information to reach the faculty and graduate students is before the student arrives for class. This information should be available as printed material and should be presented during a departmental seminar and/or during required orientation sessions for graduate teaching assistants.
- With assistance from the DSS staff and staffs of national organizations such as AAAS, science and engineering departments could assess laboratory facilities, course software, hardware, equipment, and classroom facilities specifically for accessibility and possible adaptation. Likewise, faculty who direct graduate studies could be provided with guidelines and suggestions for creating an accessible research laboratory setting. Plans of action for creating an accessible department should be drawn and work begun. Departments both within and among institutions should share their findings and ideas.
- Services and printed materials which are available from national organizations such as AAAS, HEATH, and the American Chemical Society should be disseminated widely to DSS staff and science and engineering faculty members.
- Because the doors to a future career in science and engineering can be closed early in adolescence, science and engineering departments, DSSs and other university departments should form coalitions with area community-based organizations to provide outreach activities to children in grades K-12 who have physical disabilities. In addition, outreach activities should include parents of these children. These efforts may require external funding by agencies such as the National Institutes of Health or National Science Foundation or by private foundations or businesses.
- Institutions offering science and mathematics institutes for K-12 teachers should include adaptation issues as a focus for discussion and in materials development.
- Institutional personnel who do outreach activities through the admissions office or other department should make sure that all career fairs and other recruiting activities are accessible and that their accessibility is well-publicized through appropriate routes.
- In order to provide role models for students with physical disabilities, specific efforts must be made to recruit and retain science and engineering faculty members who come to the institution with a physical disability or acquire a physical disability while at the institution. These faculty are critical role models for students who rarely have the opportunity to know a role model with a similar disability.

In summary, DSS offices have the expertise and interest which can catalyze other institution departments to create a smoother path for science and engineering students with physical disabilities. Through cooperation and resource allocation, science and engineering could cease to be a non-traditional area of study for students with physical disabilities. ■

TABLE 4.1 Regular and Student Employees of Disabled Student Service Offices by Full-time or Part-time Status

Number employed	Percentage (number) of institutions			
	Regular		Students	
	Full-time	Part-time	Full-time	Part-time
0	36% (14)	28% (11)	95% (77)	56% (46)
1	18% (7)	28% (11)	1% (1)	4% (3)
2	18% (7)	15% (6)	2% (2)	4% (3)
3	5% (2)	10% (4)	0% (0)	4% (3)
4	5% (2)	5% (2)	1% (1)	4% (3)
5	5% (2)	8% (3)	0% (0)	4% (3)
6-10	10% (4)	8% (3)	0% (0)	8% (7)
> 10	3% (1)	0% (0)	0% (0)	17% (14)
Mean (std. dev.)	2.4 (3.80)	2.0 (2.32)	0.1 (0.55)	9.0 (19.7)

Note: Only 39 and 40 institutions, respectively, could provide data on full-time and part-time regular employees.

TABLE 4.2 Student and Faculty Volunteers Working with Disabled Student Service Offices (DSSs)

Number of Volunteers	Percentage (number) of DSSs	
	Students	Faculty
0	44% (39)	79% (68)
1-5	25% (23)	19% (16)
6-10	8% (7)	0% (0)
11-15	2% (2)	2% (2)
16-20	1 % (1)	0% (0)
> 20	18% (16)	2% (2)
Mean (std dev.)	13.0 (33.72)	2.7 (16.25)

TABLE 4.3 Frequency with which Disabled Student Service Programs Encounter Student Needs in Science-Related Courses

Situation	Number (percentage) ^a of programs			
	Frequently	Sometimes	Seldom	Never
Deaf student in engineering	7 (8%)	31 (35%)	27 (30%)	27 (27%)
Quadriplegic student in chemistry	12 (13%)	30 (33%)	31 (34%)	17 (19%)
Blind student in calculus	28 (31%)	35 (38%)	16 (18%)	12 (13%)

^a Percentage of those responding (N = 90).

TABLE 4.4 Who is Responsible for Paying for Services?

Responsible Party	Percentage (number) of Institutions		
	Situation 1	Situation 2	Situation 3
SVR	15% (13)	12% (10)	20%
SVR + Inst.	35% (31)	61% (50)	40%
Institution	41% (36)	22% (18)	29%
Student + Inst.	3% (3)	1% (1)	0%(0)
SVR + Federal	1% (3)	0% (0)	0%(0)
Student Only	3% (1)	0% (0)	0% (0)
SVR + Student + Inst.	1% (3)	1% (1)	0% (0)
No funds available	0% (0)	2% (2)	0% (0)

Note: SVR = State Vocational Rehabilitation Agency;

Inst. = the college or university;

Federal = federal funds.

TABLE 4.5 Program Accessibility to Physically Disabled Participants by Program Target Group

Accessibility Issues	Program Target Group		
	Percentage Responding "No" (Number)		
	Women	Minorities	Women and Minorities
Have any physically disabled participants been involved in program since its inception?	62% (18)	75% (127)	59% (57)
	Percentage Responding "Yes" (Number)		
Could you provide or locate accommodations/technical assistance for physically disabled program participants?	77% (22)	66% (113)	73% (69)

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Nurturing Talent: Reports from the Field



Yolanda S. George

One of the greatest challenges that colleges and universities face today is preparing all students to live and function successfully in an increasingly technological society. Given the demographics projections that, by the turn of the century, minorities, women, and people with disabilities will represent an increasingly significant portion of the workforce, the challenge of increasing the number of underrepresented persons majoring and completing degrees in science and engineering becomes even more critical. This report examines how 12 universities are meeting the challenge of recruiting and retaining students from underrepresented groups in science and engineering majors.

Purpose of the Case Studies

To understand how different types of institutions create a supportive atmosphere, a series of case studies was conducted at selected institutions. This technique has been used successfully in previous work examining exemplary precollege science, mathematics, and computer science intervention programs for females, minorities, and persons with physical disabilities (Malcom 1983), and in detailing biology teaching methods which encourage female participation in precollege science (Kahle 1983). For the purposes of this study, a case study was defined as "...an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (Yin 1989).

The purpose of the case studies was to examine a diverse group of higher education institutions that have implemented efforts to increase the recruitment and retention of target groups of students and faculty. Not all of the institutions have approached this problem in the same way. Some differences in approach are due to differences in the type of institution (for example, small liberal arts colleges versus large research institutions); others result from

differences in populations served (for example, Historically Black Colleges and Universities (HBCUs) versus non-HBCU women's colleges). Individual case studies explored some or all of the following questions:

- How do different types of institutions perceive the problems of a narrow science and engineering pipeline for women, minorities, and physically disabled students? How have they examined how this problem manifests itself at their institution? Have they made efforts to solve the problem(s)? What types of efforts have been made, and what is their place in the institution—both now and in the future? What has been their result?
- If institutions have implemented specific targeted programs (for example, women in engineering programs), how do those programs function within the institution in terms of housing and staffing? Also, is there coordination of those efforts across departments or schools and across disciplines?
- If institutions approach these problems through non-targeted programs (such as through the admissions office), is a focus on science and engineering maintained? That is, how are the specific problems of the science and engineering pipeline addressed?
- How does the general campus climate relate to science and engineering efforts? Are both the campus climate and science and engineering efforts (whether through targeted programs or non-targeted services) synchronized? What evidence is there for a positive or negative campus climate for women, minorities, and physically disabled students and staff members? Does the positive or negative nature of the campus climate affect the success of targeted and non-targeted programs in increasing the participation of women, minorities, and physically disabled students and faculty in science and engineering?

Selection of Case Study Institutions

In selecting the institutions for case studies, several factors were considered. First, the case studies were not selected to be representative of the nation as a whole (Yin 1989). Rather, the case study institutions were selected to provide information on a diverse group of institutions that may or may not approach the issues of recruitment and retention of underrepresented groups in science and engineering in the same ways or with the same levels of success.

In order to begin the selection process, a series of selection criteria were applied to the list of 276 institutions participating in the study. First, each institution must have responded to the "Survey of Presidents/Chancellors" and provided information on programs/services which promote the recruitment and retention of at least two of the target groups of students. From this initial pool, institutions were selected so that the final group of case study institutions would be diverse in terms of four primary factors.

1. The size and Carnegie Type of the institutions
2. The geographic location of the institutions

3. The primary population served by the institution, such as women, various minority groups, and physically disabled students
4. The types of programs and services utilized by the institution to increase recruitment and retention of the target groups

Finally, the list of possible institutions for case study was revised according to the interest expressed by the institutional personnel in participating in the case study phase of the study. The final list of case study institutions (Figure 5.1) represents a diverse group of institutions in terms of all of the criteria listed above. For purposes of discussion, the institutions are grouped as follows: Historically Black Colleges and Universities; Minority Institutions; Traditionally Women's Colleges; and Predominantly Majority Universities. Experienced case study researchers were selected for each institution (Figure 5.1). The case study protocol is detailed further in Appendix B.

Figure 5.1 Case Study Institutions and Research Team Members

Institution	Researcher
1. Historically Black Colleges and Universities (HBCUs)	
Jackson State University	Yolanda S. George, AAAS
North Carolina A&T University	Willie Pearson, Jr., Wake Forest University
University of Maryland, Eastern Shore	Willie Pearson, Jr., Wake Forest University
Spelman College, Georgia	Yolanda S. George, AAAS
2. Minority Institutions (MIs)	
University of Puerto Rico	Yolanda S. George, AAAS
3. Traditionally Women's Colleges (TWCs)	
Smith College, Massachusetts	Beatriz Chu-Clewell, Educational Testing Service
Spelman College, Georgia	Yolanda S. George, AAAS
Wellesley College, Massachusetts	Beatriz Chu-Clewell, Educational Testing Service
4. Predominantly Majority Universities (PMUs)	
Northern Arizona University	Sue Kemnitzer, Federal Task Force*
San Francisco State University, California	Virginia S. Stern, AAAS
University of Alabama, Birmingham	Yolanda S. George, AAAS
University of Florida, Gainesville	Evangeline McJamerson, Louisiana State University
University of Washington, Seattle	Shirley M. Malcom, AAAS

* Federal Task Force on Women, Minorities and the Handicapped in Science and Engineering

Using these methods, this report examines a variety of strategies for recruiting and retaining underrepresented students in science and engineering at both the undergraduate and graduate levels; presents general findings about these efforts; and identifies science and engineering challenges for expanding these efforts at colleges and universities.

Science and Engineering Undergraduate Recruitment Programs and Strategies

Although faculty and administrators in science and engineering departments recognize the need to expand the science and engineering pipeline, many institutions still depend upon limited and traditional methods for recruiting undergraduate students. These traditional methods include visits to high schools and junior colleges, and college and career days. Often recruitment is the responsibility of a person who does university-wide recruitment. In some cases, colleges and universities have recruiters whose sole job is to recruit minority students.

Some science and engineering schools and departments of colleges and universities in this study have set up their own offices for both recruitment and retention. For example, the Schools of Engineering at the University of Washington (Seattle), University of Alabama (Birmingham), and the University of Florida (Gainesville) have special offices. Although these offices are more prevalent in schools of engineering, the University of Maryland, Eastern Shore, School of Agriculture has an office for the Agriculture Science Project. Staff in these special offices are responsible for recruitment, retention, management, and fund raising for student financial aid, academic enrichment programs, and tutoring programs.

Many colleges and universities identify and prepare students for science and engineering majors through special K-12 science- and mathematics-based programs developed by faculty and/or staff in academic or administrative offices or centers. These programs include one or more of the following components:

- Precollege academic-based programs for elementary and/or high school students
- Teacher training programs for elementary and/or high school teachers
- Partnerships that help strengthen science and mathematics programs offered by local elementary and/or high schools

Examples of precollege academic-based programs for elementary and high school students include:

- Six-week summer residential programs for minority students, including courses, research, and career and college counseling. Programs at Jackson State University, Northern Arizona University, and the University of Puerto Rico are funded by the National Science Foundation's Young Scholars Program and ACCESS program. The Northern Arizona University project is also funded by the American Chemical Society's Project SEED.

- A five-week summer program designed to prepare minority eleventh and twelfth grade high school students for university calculus at the University of North Carolina A&T, funded by the U.S. Department of Energy, PREFACE Program.
- High school clubs or chapters which provide counseling on engineering careers and college admissions requirements and tours of engineering schools for minority students. Such clubs are sponsored by the Southeastern Consortium for Minorities in Engineering (SECME) at North Carolina A&T University and the Mathematics, Engineering, and Science Achievement (MESA) Program at both San Francisco State University and the University of Washington, Seattle.
- Saturday academy programs which provide 4-6 hours of activity-based science and mathematics for K-12 minority students. Spelman College and the University of Puerto Rico operate programs at the elementary, junior, and senior high school levels.
- High school minority research apprenticeship programs which give students the opportunity to do summer research. The University of Alabama, Birmingham and the University of Puerto Rico conduct such programs.
- Science and mathematics-based contests and competitions. North Carolina A&T University participates in the Mathematics/Science Olympics and the University of Puerto Rico operates a Science and Math Bowl.
- Science and engineering workshops and conferences for girls and young women. Future Scientists/Future Engineers Workshop for high school girls is a day-long activity at Smith College which includes hands-on experiments, interaction with female college science majors, panel discussions with women scientists and engineers, and a tour of the Clark Science Center. San Francisco State University chapter of the Society of Women in Engineers organizes Expanding Your Horizons career and college conferences at the university and the Sleep Over Science Program for Girl Scouts at The Exploratorium science museum.

These programs not only help to academically prepare students for college, but they also introduce students to the university environment and provide information on financial aid.

Often universities sponsor training programs for elementary and/or high school teachers as part of their overall recruitment intervention strategies.

- The University of Puerto Rico operates a four-week summer workshop to provide teachers with necessary skills to communicate basic concepts, develop cognitive skills in science and mathematics, and learn to use novel teaching strategies. Eight Saturday follow-up sessions provide additional experiences in teaching concepts and strategies, encourage incorporation of materials into the classroom, and provide feedback on the effectiveness of activities developed during the summer.

- Northern Arizona University sponsors a variety of inservice teacher training workshops to help teachers make the science and mathematics curriculum more culturally relevant for American Indian students.
- Smith College offers a program for high school science teachers and counselor teams designed to address the underrepresentation of women in science and engineering. Teams participate in a two-and-a-half day workshop which includes lab experiments, discussion of issues related to the underrepresentation of women in science (such as sex stereotyping), and discussion with women scientists and engineers. After the workshop, teachers develop a plan of action to encourage girls at their school to participate in science classes.

Partnerships between schools and colleges have been pursued to strengthen the overall mathematics and science programs at the schools.

(1) The University of Puerto Rico is establishing a formal school-based partnership with selected schools. Components of this partnership include the preparation of master teachers in science and mathematics, the development of a science education resource center with curricular materials, technical assistance for teachers from university professors, and the establishment of university student teacher programs in the schools.

(2) Northern Arizona University has adopted the Tuba City High School and is redesigning and strengthening the science and mathematics programs. Tuba City High School, located on a American Indian reservation, is operated by the U.S. Department of the Interior, Bureau of Indian Affairs, and the local tribal government. The university is exploring the possibility of operating the school.

In summary, findings about science and engineering recruitment efforts at colleges and universities in this study are:

- In general, most undergraduate recruitment efforts at HBCUs, MIs and PMUs focused on minorities. Although recruitment programs were almost never specifically aimed at girls and young women, a large percentage of the minority students participating in recruitment and outreach programs were female.
- Two of the three Traditionally Women's Colleges (TWCs) in this study did not have specific programs to recruit girls into science and engineering.
- None of the universities had specific programs to recruit students with disabilities into science and engineering.
- Schools of engineering had more recruiting efforts than schools or colleges of science.
- Undergraduate academic outreach efforts were more likely to focus on recruiting students than on strengthening teachers and schools.

Science and Engineering Undergraduate Retention Efforts

In terms of undergraduate retention efforts for minorities and women, the strongest models were found in schools of engineering. In most schools of engineering students arrive with the declared intention to major in engineering. Such a declaration is crucial to identifying, tracking, and assisting students from underrepresented groups who are in these programs. Established minority programs exist because of the long-term effects of a national engineering effort as coordinated through the National Action Council for Minorities in Engineering (NACME) and its predecessor organizations. Such programs often provide tutoring, supplemental courses in mathematics/chemistry/physics, peer support networks, financial aid, and faculty interaction. Such programs were identified in case studies at the University of Washington, Seattle; Northern Arizona University; University of Alabama, Birmingham; North Carolina A&T University; and San Francisco State University. Established women's programs exist at majority colleges and universities in large part because of the efforts of the Society of Women Engineers. Women in engineering efforts were identified at the University of Washington, San Francisco State University; University of Alabama, Birmingham; and Smith College.

On the other hand, minority and female students who are interested in non-engineering science majors do not build connections to these departments until their junior or senior year of college. These students usually depend upon academic support and counselling that is a component of an office of student affairs. This office typically provides general academic services, tutoring, personal and career counseling and special services for minority, women, and disabled students. For the most part, tutoring tends to be limited to English and mathematics. Tutoring is rarely available in chemistry and physics. In some cases, students, such as those at Jackson State University and Spelman College, organize informal tutoring groups in chemistry and physics.

If minority students interested in science survive their freshman and sophomore college years, they are eligible to participate in undergraduate research programs. The most renowned programs are those of the National Institutes of Health, the Minority Biomedical Research Support Program (MBRS), and the Minority Access to Research Careers Program (MARC). These programs provide junior and senior college students with research experiences, special seminars and workshops, travel to professional science meetings, tuition and stipends, and information on graduate schools. The programs are targeted at Historically Black Colleges and Universities (HBCUs), Minority Institutions and Predominantly Majority Universities which enroll a substantial minority population. In this study MBRS and MARC programs were identified at Jackson State University, North Carolina A&T University, Spelman College, Northern Arizona University, and the University of Puerto Rico.

One school of science in this study that has adapted the retention approach used by schools of engineering is the University of Maryland, Eastern Shore, School of Agricultural Science. The Office of Agricultural Science Project is funded by the U.S. Department of Agriculture.

Another strategy for increasing the retention of college students is the summer bridge residential program. Spelman College, Division of Natural Sciences, offers a pre-freshman Summer Science Program. This program provides intensive instruction and academic enrichment in biology, mathematics, chemistry, computer science, problem solving, and reading. In addition

to providing academic support, this program allows students to make social adjustments to college life. This program is targeted toward students interested in health careers and is sponsored by the U.S. Department of Health and Human Services.

In summary, four conclusions may be drawn relating to undergraduate retention based on this study.

1. Retention strategies identified at colleges and universities in this study include: establishment of academic support offices in the School or College of Sciences or Engineering; pre-freshman bridge programs; and undergraduate research programs
2. At majority colleges and universities and HBCUs/MIs, schools of engineering had more established retention efforts than did schools or colleges of science
3. Schools or colleges of sciences at all types of universities in this study had strong retention efforts in the form of undergraduate research initiatives for junior and senior year undergraduate students. No specific retention efforts were identified for freshman and sophomore undergraduate students interested in science
4. No specific programs related to retention of students with disabilities were identified at universities in any of the case study sites

Science and Engineering Graduate School Recruitment and Retention Efforts

At HBCUs/MIs, students were tracked toward graduate school in their junior year of college through early identification programs at their colleges, such as the MARC and the MBRS programs. HBCUs/MIs also hosted graduate and professional school days for recruiters from other HBCUs/MIs and majority institutions. MARC and MBRS programs were identified at Spelman College, North Carolina A&T, Northern Arizona University, Jackson State and the University of Puerto Rico.

Other colleges in this study have developed early graduate school identification programs. For example, the University of Maryland, Eastern Shore campus and Baltimore campus established an Honors Program to attract minorities to professional schools. Undergraduate students in these programs are provided with academic advisors, mentoring, access to faculty and staff, test-taking skills workshops, off-campus trips, and internships. Students who are a part of this program and apply to the Baltimore campus for professional school do not compete with the vast number of applicants. These students are given preferential consideration, but are not guaranteed admission to professional schools.

At Smith College the dual-degree program in liberal arts and engineering enables female students to receive an A.B. from Smith and a B.S. in engineering from the University of Massachusetts School of Engineering in five years, or an M.S. in engineering in five or six years. The program's goal is to provide female undergraduates with a strong liberal arts education and the opportunity to train in an engineering field and go on to top graduate programs in engineering and industry. This program provides summer research in academic or industrial settings, panels and presentations with female engineers, and site visits to high-tech companies.

Similarly, majority colleges and universities identify minority undergraduate students who are interested in graduate schools through consortium programs for graduate education. For example, several colleges and universities in this study participate in the Graduate Engineering Degrees for Minorities Program (GEM). GEM is a consortium of colleges, universities, corporations, and agencies which identify minority students in their junior and senior year and prepare them for graduate school in engineering. Students in the GEM program receive financial aid, summer research opportunities, and fellowships for graduate school. A science component has recently also been added to GEM.

Northern Arizona University is a founding member and is also the location for the Consortium for Graduate Opportunities for American Indians. This is a group of fifteen colleges and universities which supports activities to increase the participation of American Indians in graduate schools. Activities include workshops and newsletters for students and faculty and technical assistance to help students find financial aid for graduate school.

The University of Alabama, Birmingham is a member of the National Consortium for Equal Access (NCEA). This consortium is a partnership among HBCUs, Ph.D. degree granting universities, and corporations, designed to increase the pool of Blacks available to teach at the college and university level. The NCEA offers financial aid to students enrolled in participating universities.

Most majority colleges and universities use multiple strategies to recruit minority graduate students. These strategies include:

- A subscription to the Minority Graduate Student Locator Service. This is a Graduate Record Examination (GRE) sponsored service that offers computerized mailing labels of minority students. Labels are used for special mail campaigns. Students who respond to the mailing receive personal letters from the Dean of the Graduate School.
- Recruitment as part of the U.S. Department of Education Patricia Robert Harris Fellows Program. Announcements and posters are distributed to science and engineering departments and placement offices.
- Membership in one or more graduate school consortia.
- Partnerships with HBCUs/MIs.
- Participation in special on-campus recruitment events. Activities include displaying literature in lobbies at the student center with graduate school representatives present to answer questions and participating in career days and special seminars.
- Participation in off-campus recruitment events such as the Atlanta University Center Annual Conference and forums of the Graduate Record Examination Board and Council of Graduate Schools of the United States.

At the graduate school level, more attention is focused on recruitment than on retention although efforts often occur in the form of "trouble-shooting" individual student problems. The only graduate retention effort identified was located at the University of Florida, Gainesville. The purpose of this program is to increase the number of minority students, regardless of major, enrolling in

and completing the university's graduate programs. Retention activities include a pre-graduate school summer program which provides seminars about academic programs and policies, available support services, and the social environment. Workshops offered during the academic year include research methodology, writing, statistics, and computer science. New students also participate in an orientation program.

At the University of Washington, Seattle and the University of Florida, Gainesville graduate recruitment and retention efforts are managed by associate deans for minority graduate affairs.

In summary, findings about graduate school recruitment and retention efforts in science and engineering are as follows.

1. Two key graduate school recruitment strategies identified by all the colleges and universities in this study were undergraduate research initiatives and membership in graduate school consortia.
2. At majority colleges and universities and HBCUs/MIs, graduate recruitment and retention efforts were aimed at minorities. Two of the majority universities visited had established an associate dean of minority affairs position and an office to deal with minority recruitment and retention.
3. The only graduate school retention program identified in these visits organized workshops in statistics, computer science, and writing for incoming graduate students though not specifically targeted for science/mathematics/engineering majors.

Science and Engineering Challenges for Colleges and Universities

Challenges at HBCUs/MIs and Traditionally Women's Colleges

The main science and engineering challenge for HBCUs/MIs and Traditionally Women's Colleges is achieving appropriate balance of research efforts in largely teaching institutions. Strategies for achieving this balance have included developing dual degree and cross registration programs with other universities; centralizing science and engineering resources into centers; and developing consortia with other colleges and universities, corporations, and national laboratories for both faculty development, undergraduate curriculum reform, and research opportunities programs.

In an effort to expand degree offerings, HBCUs/MIs and Traditionally Women Colleges have developed dual degree and cross registration programs. Spelman College has cross registration programs with Clark-Atlanta University, Morehouse College, and Morris Brown College to expand its course majors offerings in physics and chemistry. Programs in science and engineering at Spelman are coordinated through the Atlanta University Center Dual Degree Program. Universities participating in this dual degree program include Georgia Institute of Technology, Boston University, Auburn University, and Rochester Institute of Technology. Dual degree programs were also identified at Jackson State University, Smith College, and Wellesley College.

To strengthen both science education and research, universities have centralized their science resources. At Jackson State University, the School of Industrial and Technical Studies and the Division of Natural Sciences were

merged to form the School of Science and Technology. The Science Center at Wellesley brings together all the science departments, including mathematics and computer science. The Clark Science Center at Smith College brings together in a three-building complex classrooms, laboratories, faculty offices, lecture halls, a rooftop observatory, a computer terminal room, and a science laboratory.

HBCUs/MIs also have formed consortia to expand their science and engineering education and research programs. Jackson State University is a member of a number of consortia with corporations, national laboratories, and other HBCUs/MIs. Wellesley, Smith, and Spelman Colleges are members of a women's college network. A major consortium for science and engineering is coordinated through the University of Puerto Rico (UPR). In 1980 the University of Puerto Rico established the Puerto Rico Resource Center for Science and Engineering. Over an eight year period, staff at this center developed a holistic approach to science education which involves working with disadvantaged Puerto Rican students throughout the K-12 and college and university education pipeline. In 1989, the Center formed a consortium with the Commonwealth Department of Education and several two-year and four-year colleges and universities to establish the Comprehensive Regional Center for Minorities (CRCM). The main objective of the CRCM is to expand science education and science and engineering research efforts throughout the entire island. Colleges and universities that are a part of this consortium include: Catholic University, Interamerican University, Ana G. Mendez Foundation, Puerto Rico Junior College, University of Puerto Rico System, Cayey College, regional colleges, Sacred Heart University, UPR Graduate Center, UPR Mayaguez Campus (Engineering), UPR Rio Piedras (Natural Science), and UPR Medical Center Campus (Basic Science).

The CRCM was conceptualized after going through a planning phase including the following key stages:

- Systematic assessment of available resources
- Identification of the needs of the educational system at all levels
- Development of a comprehensive plan of action that had enough structure to be effective, and the necessary flexibility to react to changing circumstances

Components of the CRCM programs include precollege and undergraduate initiatives. Subcomponents of the precollege components are intervention programs for tracking talented students in grades 7-12 to enriched academic programs; continuing education for precollege teachers; an institute for the development of master teachers; and school-based programs. (These programs are briefly described in Table 5.1.)

The undergraduate component of CRCM includes student enrichment programs; undergraduate student education development; and, faculty development. (Table 5.2 briefly describes each subcomponent of the undergraduate components.)

In order to develop broad-scale research initiatives in Puerto Rico, UPR and other members of the CRCM have initiated two major research initiatives: the Experimental Program to Stimulate Competitive Research (EPSCOR) in Puerto Rico and the Minority Research Center for Excellence Project. Both of these efforts, funded by the National Science Foundation and other government agencies and corporations, are designed to:

- Effect positive changes in the research environment in Puerto Rico
- Develop a cadre of top-notch minority researchers
- Promote government and university policy changes to increase science and engineering research in Puerto Rico
- Promote research opportunities for minority students at graduate and undergraduate levels

Areas of research for EPSCOR include physics, chemistry, computational mathematics, engineering, geology, marine ecology, cell biology.

The Minority Research Centers for Excellence project is focusing on the development of four centers: Caribbean Geology; Marine Natural Products (Chemistry); Terrestrial Ecology; and Mitigation of Natural Hazards (Engineering).

To foster and promote collaboration between academia and local industry, the Chancellor of the Mayaguez Campus has appointed an Industrial Advisory Council of 15 chief executive officers. Other partners in the UPR research initiative are the Puerto Rico Economic Development Administration of the Commonwealth Government and Puerto Rico Community Foundation.

In summary, achieving an appropriate balance of research efforts in a largely teaching institution requires reorganizing and maximizing existing science resources and forming collaboratives with a variety of institutions, including other universities, corporations, national laboratories, government agencies, and private foundations.

Science and Engineering Challenges for Predominantly Majority Universities

Since the college age population will be increasingly minority, the major challenge for majority colleges and universities is planning for diversity. Strategies for planning for diversity were identified at the University of Alabama, Birmingham; University of Florida, Gainesville; University of Washington, Seattle; Smith College; and Wellesley College. Strategies include:

- equity statement in the mission statement of the university. The University of Arizona already includes a statement;
- establishing faculty and staff task forces or committees on diversity. Task forces or committees were identified at Smith College, Wellesley College; University of Alabama, Birmingham; and the University of Florida, Gainesville;
- creating Offices of Minority Relations. Such offices exist at the University of Alabama, Birmingham; University of Florida, Gainesville; and the University of Washington, Seattle;
- establishing staff and academic positions related to increasing diversity.

Northern Arizona University has undertaken the major thrust of developing programs to increase the number of American Indians in science and engineering. The University's plan of action includes frequent contact with tribal councils, precollege teachers, parents, and students through:

- Programs focusing on early intervention, including strengthening mathematics and science at American Indian reservation schools
- Summer programs for K-12 American Indian students to bridge the cultural, psychological, and intellectual gap between the reservations and the university
- Undergraduate research programs for American Indian students through the MBRS and MARC initiatives
- A partnership with Navajo Community College to offer fully-articulated pre-engineering programs
- Establishment of the Native American Cooperative Forest Multi-resource Program. Its broad goal is to support American Indian tribes in achieving self-determination in the management of their forest lands. This takes the form of increasing the number of American Indians who have undergraduate and graduate degrees and developing research initiatives that address forest management
- Establishment of the Consortium for Graduate Opportunities for American Indians

Thus, achieving diversity on majority campuses requires examining existing efforts, creating new offices and staff positions, and reaching out to minority communities.

Science and Engineering Challenges for All Universities

From the case studies, four challenges were identified for all universities:

1. Coordination of existing student recruitment and retention efforts to increase services for science and engineering students
2. Defining admission policies, other than grades and test scores, to identify college-ready students
3. Developing recruitment and retention programs to attract students with disabilities to science and engineering
4. Attracting minority science and engineering faculty

Universities already have offices for university-wide recruitment and retention. Many of the staff in these offices are unfamiliar with strategies that have been developed to recruit and retain minority, women, and disabled persons in science and engineering. Thus, there is a need for articulation between these offices and schools of sciences and engineering. Such articulation could improve recruitment and retention across the university.

Several universities in this study are grappling with ways to redefine undergraduate admission policies. For example, at Wellesley College, when admissions credentials of minority students fall below the regularly used criteria there is an additional review process called "Minority Review" where members of the board look for factors beyond grades and test scores. This review is done to "get a sense of what role models these students have had in their lives, their self-perception, their motivation, and their environmental factors." At the

University of Florida, Gainesville, a Board of Regent's policy permits up to ten percent of the students admitted at any level during the academic year to be exceptions to the minimum standard.

In terms of recruiting and retaining students with disabilities, none of the universities in this study had specific programs in science and engineering. However, the University of Alabama, Birmingham, University of Florida, Gainesville, Wellesley College, and Smith College had strong general disabled student services. For example:

- To enable students with disabilities to fulfill the Wellesley requirement that every student (without exception) take a lab as part of the college science requirements, special equipment has been installed.
- At the University of Florida, Gainesville several kinds of equipment and supplies are available on a short-term loan basis. Equipment includes a Braille typewriter and dictionary, a large-print dictionary, an IBM computer for the visually impaired, a Braille terminal, and a reading machine which converts printed material into synthetic English speech.
- The University of Alabama, Birmingham offers a variety of services for students depending on the type of disability (Table 5.3).

Since minorities represent about 2% of the Ph.D. science and engineering workforce, colleges, and universities are looking for ways to recruit Black, Hispanic, and American Indian faculty. Strategies for recruiting minority faculty include:

- establishment of special committees
- creating minority faculty vitae banks
- senior mentor programs for scholarly development of non-tenured minority faculty
- providing limited financial assistance for doctoral study to minority graduate students who, upon completion of their degree, will seek employment at the university
- implementation of special post-doctoral programs aimed at new minority Ph.D.
- full or partial funding of positions for Ph.D. minority faculty from the President's or Chancellor's fund for a limited period of time

Conclusion

Although colleges and universities do not routinely keep records of the persistence and graduation rates of minority and women students in science and engineering (see Chapter 2), there is anecdotal evidence that recruitment and retention programs in site-visited institutions are working. The most effective undergraduate recruitment strategies are academic-based programs that establish relationships or partnerships with students, teachers, schools. Educators generally agree that the two most significant factors in whether or

not a student chooses to go to a particular college or university are early financial aid notification and familiarity with the environment and learning climate at the college or university.

The most effective undergraduate retention strategies appear to be those that create a community for students in science and engineering, provide supplemental calculus/chemistry/physics workshops for freshman and sophomore college students, and provide undergraduate research learning experiences. From what little can be gathered about graduate school recruitment and retention, the most effective way to recruit and retain minorities and women is through early identification at the undergraduate level.

To solidify and expand the pool of underrepresented students who go into and succeed in science and engineering, colleges and universities must restructure academic and support services across the institution. This restructuring process will take time and will require input from administrators, faculty, and trustees of colleges and universities.

Most of the interventions devised by colleges and universities are aimed at enabling students and/or faculty from underrepresented groups to fit into, adjust or negotiate the existing system. There is little challenge to the structures that currently exist. For example, the focus of faculty recruitment and retention is finding people who can survive in the current models. It becomes a tougher institutional challenge to rethink those models, whether it is the role of research in a primarily teaching institution or the role of teaching in a research university. The reconfiguration of the reward/incentive structure is seldom discussed as a means to achieve the appropriate balance between these functions of a college or university. In like manner most existing efforts with students have been designed to enable them to succeed in courses as they are currently structured. The pipeline leaks directly attributable to introductory "killer courses" in chemistry, calculus and physics are more likely to precipitate student rather than curriculum oriented intervention. An exception to this was achieved in some of the science courses within the University of Washington. For example, the innovative physics program developed to address the limited experiences and misconceptions which many minority students bring to that subject and which carry over to their advanced study of science and engineering has proved to be highly effective in enhancing minority student participation and success in such fields (McDermott, Piternick, and Rosenquist 1980).

A coherent, coordinated, articulated structural approach to enabling students from underrepresented groups to succeed in science, mathematics, and engineering programs has yet to be achieved by the institutions. Within the special project structure, which is the most common intervention strategy, we find that these models support enhanced learning for all students not only for the underrepresented students for whom they may have been originally designed. Perhaps programs for women, minorities, and disabled students can once again point the way toward structure reform within science/mathematics/engineering programs that provides excellent education for everyone (Malcom 1983). Specific recommendations for institutional policies and practices are outlined in Chapters 2 and 6. ▲

TABLE 5.1 University of Puerto Rico Pre-College Component: Summary of Activities

INTERVENTION PROGRAMS FOR TEACHING TALENTED PRE-COLLEGE STUDENTS	
Summer Camp Program for 7th and 10th Graders	A six-week, total immersion, residential, university-based program for students (66% from low income families) is aimed at developing cognitive and communication skills in math and science and motivating the study of science and math. Parental involvement is an integral part of this program.
Saturday Academy Program for Elementary School Students	Talented science and math students (66% from low income families) are identified and provided with day-long motivational activities based on exploratory and experiential approaches once a month, on Saturdays. Parental involvement is an integral part of this program.
Saturday Academy Program for Junior and Senior High School Students	Students who have participated in a previous Summer Camp return to the university once a month (8 Saturdays per year) for formative and motivational activities that will assure the acquisition of basic concepts and skills in math and science and motivate the study of science and math.
Research Apprenticeship Program for High School Students	Students participate in research projects during the summer in a university environment; the most talented continue their research with the help of their faculty mentors during the academic year. Parental involvement is an integral part of this program.
Motivational Program for Students	Sponsorship of activities such as Science and Math Bowls, Competitive Exams in Biology and Physics, and the Science Congress, that motivate students to study and excel in science and math.
CONTINUED EDUCATION FOR PRE-COLLEGE TEACHERS	
Comprehensive Summer Workshop Training Program for Elementary and Secondary Science and Mathematics Teachers	Four-week workshops are held to provide teachers with the necessary skills to communicate basic concepts, develop cognitive skills in science and math, and learn to use novel teaching strategies. Eight Saturday follow-up sessions provide additional experiences in teaching concepts and strategies, encourage incorporation of learned material into the classroom, and provide feedback on effectiveness of activities developed during the summer.

TABLE 5.1 continued

CONTINUED EDUCATION FOR PRE-COLLEGE TEACHERS	
Chautauqua-Type Short Courses for Pre-college Science and Mathematics Teachers	Courses consist of four-day workshops offered by outstanding science and math specialists, that update and expand teachers' knowledge and skills. Teachers develop curricular materials for teaching new or difficult concepts.
INSTITUTE FOR THE DEVELOPMENT OF MASTER TEACHERS	
Master Science and Mathematics Teachers Program	An intensive three-year program that develops Master Science and Mathematics Teachers by giving them breadth and depth in their fields through non-traditional courses, activities, and leadership seminars. Upon completion of their training, these teachers resume their work with Commonwealth Department of Education where they serve as resource teachers for development of curriculum and train their peers in their school districts.
SCHOOL-BASED PROGRAMS	
Model Partnership with Public Secondary Schools	Selected public schools are developed as model schools to serve as mechanisms for transferring educational strategies and materials produced by the Comprehensive Regional Center for Minorities into a school-based environment and to serve as places where student teachers can do their practicum.
Educational Resource Centers	Centers are created where Master Teachers, Comprehensive Regional Center for Minorities workshop participants, and faculty of model partnership schools develop curricular materials, obtain information on existing curricular materials, and receive consulting services from college professors.

Note: Adapted from UPRCRC 1989.

**TABLE 5.2 University of Puerto Rico Undergraduate Development Component:
Summary of Activities**

STUDENT ENRICHMENT SUBCOMPONENT	
Summer Research Apprenticeship Program	Student research skills are strengthened by participation in high-quality research programs at graduate centers. Learning new experimental techniques using sophisticated instruments, well-equipped libraries, and computer equipment develops cognitive critical thinking and research skills among participants.
Puerto Rico Interdisciplinary Scientific Meeting (PRISM)	Students present their work to peers and scientists in an interdisciplinary meeting that helps them develop research and communication skills. Research collaboration among campuses and institutions in the Consortium is promoted by this activity.
Student Seminars, Workshop, and Lecture Series in Science and Mathematics	Students participate in seminars, lectures, and workshops designed to increase their motivation toward graduate studies. Orientation lectures create awareness of opportunities for graduate studies in Puerto Rico. Informational lectures on recent advances in scientific research in Puerto Rico and the mainland keep participants up to date in science and mathematics.
UNDERGRADUATE EDUCATION DEVELOPMENT SUBCOMPONENT	
Seminar on the Application of Cognitive Science to the Teaching of Science and Mathematics	An interdisciplinary cadre of 40 faculty members from the Consortium institutions participates in a seminar at which experts in the field of cognitive science present the latest applications to the teaching of science and mathematics. This group collaborates in the elaboration of a broad plan to implement change and serves as advocate for the improvement of the teaching of science and mathematics in their institutions.
Curricular Material Exchange Program	Locally and nationally available quality curricular materials are identified and their dissemination promoted among members of Consortium. A library of reference materials and educational resources evaluated by nationally recognized consultants will be established.

TABLE 5.2 continued

UNDERGRADUATE EDUCATION DEVELOPMENT SUBCOMPONENT	
Collaborative Program for the Development of Curricular Materials	Faculty submit proposals for the development of innovative curricular materials. Funds are granted on a competitive basis; priority is given to those projects that emphasize student mastery of higher order cognitive and critical thinking skills.
FACULTY DEVELOPMENT SUBCOMPONENT	
Short Courses and Workshops for the Continued Education of Faculty	Short Courses and Workshops by local and nationally renowned educators provide faculty with up-dated information on recent developments in their field. Continued education for faculty in the applications of cognitive science, and innovative and effective educational methodologies leads to development of quality materials for the courses taught by participants.
Faculty Mini-Sabbaticals	Faculty with limited research experience have the opportunity to work during the summer in research laboratories at the Graduate Centers to refine their skills and to motivate them to become involved further in research. Their skills are developed to prepare competitive research proposals for the Comprehensive Regional Center for Minorities Collaborative Research program. Participating non-Ph.D. faculty are encouraged to continue graduate studies and complete their Ph.D. degrees.

Note: Adapted from UPR 1989.

Table 5.3 Services for Students with Disabilities

Service Offered	Type of Disability				
	Mobility	Vision	Hearing	Health-Related	Learning
Classroom accommodation/relocation	X				
Screen for personal attendants	X				
Assistance in securing note-takers/scribers/tutors	X	X	X	X	
Environmental consultation/manipulation	X			X	
Priority housing assignments	X	X		X	
Assistance in applying for auxiliary aids	X	X	X	X	X
Alternative test formats and administration	X	X		X	
Pre-registration and orientation assistance	X	X	X	X	
Advocate for the student	X	X	X	X	X
Individual counseling regarding personal concerns	X	X	X	X	X
Alternative formats (Braille, Large print, Cassette) for educational texts		X			
Apollo portoreader, taped dictionary, talking book machine, and tape recorders available for studying and test-taking		X			
Assistance with securing interpreters and coordinating schedules			X		

Table 5.3 continued

Serviced Offered	Mobility	Vision	Hearing	Health-Related	Learning
Introductory letters to instructors		X	X		
Providing carbonless note-taking paper			X		
TDD access			X		
Referral to the State Vocational Rehabilitation Services or private examiner for testing					X
Process letters to instructors (with student's permission) disclosing their learning disability and suggested accommodations					X
Assist student in getting educational texts on tape					X
Administer or proctor academic or standardized tests					X

Note: Adapted from University of Alabama, Birmingham 1989.

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More than Market Forces: Policies to Promote Change



Shirley M. Malcom

During the decade of the 1990s, colleges and universities in the United States will face a significant challenge. These institutions will be called upon to educate a student population that has a smaller 18 to 24 year-old component and that is more racially, ethnically, and culturally diverse than at any time in the history of our country. Perhaps nowhere will this challenge be felt more strongly than in the departments, divisions, schools and colleges that organizationally encompass natural sciences, mathematics, and engineering. It is in these fields that the greatest discrepancy exists between the available college-age population, who will be primarily women and/or minorities, and the usual participants in such programs, who are mostly White males. Developing strategies to draw the talents of American Indian, Black, and Hispanic men, women of all racial and ethnic groups, and people with disabilities into science and engineering will require commitment by many different groups: by the larger communities of professionals in these fields, by the institutions that educate and hire, and by the larger science policy structures which direct the flow of resources to sustain the scientific and engineering research and resource base of this country. The weak tradition of participation among underrepresented groups in science and engineering fields means that welcoming rhetoric and market forces alone will prove insufficient to attract and retain these students and to create a strong and diverse workforce.

The fact of underparticipation by female, minority, and disabled students has been documented in this report and elsewhere. The reasons are beginning to be understood; but the underlying problems have not yet been addressed in ways that will bring about necessary large-scale changes in levels of participation. During the past decade, American students decreased their participation in graduate education as foreign students increased their interest and participation in graduate education programs in the United States, especially in engineering, mathematics, physics, and computer science. The changing population of students participating in and available to science, engineering, and mathematics has led to an increased interest by the policy community in the human resources activities of U.S. colleges and universities. Why are so few minorities, women, and students with disabilities making it through higher

education in these fields, and why are decreasing numbers of traditional participants, (that is White American males), also choosing not to pursue study in science, mathematics, and engineering?

A study by the Office of Technology Assessment (1989) identified the need to look at strategies related to recruitment and retention in science and engineering, especially in higher education. How many students are attracted to undergraduate study of science and engineering? How many of these students are retained to graduation? How many are introduced into the graduate portion of the pipeline? As we look at the population of underrepresented students, we must also ask questions about the readiness to participate that must precede recruitment, and restructuring of programs that must accompany retention. How full is the pipeline and how prepared are the students in it to pursue study in science and engineering fields? How strong is the attractive power of science and engineering fields compared with opportunities available in other areas, especially for the most highly recruited students? How prepared is the institution to educate the students, and how committed is the institution to provide experiences which will hold them to the school and within the majors? And, how accepting is the climate of the institution to the changes that may be necessary within the school, department, and field to meet the needs of these diverse students and to develop their talents fully?

The answers to these questions differ depending on the race, sex, and socioeconomic levels of the students being discussed. They also differ depending on the colleges and universities that these different students attend. In the study documented in this report, many institutions did not collect data in a form that would allow them to assess how well they were recruiting and retaining underrepresented students within their programs in mathematics, science, and engineering. In other instances, available information did not inform institutional policies or practices.

Many institutions were unable to provide information about the sex, race or ethnicity of undergraduate majors, the graduation rate of these students, or the sex, race or ethnicity of graduate students. Predictably, data for science and engineering students with disabilities was virtually non-existent.

Past studies have documented the differential role of Historically Black Colleges and Universities in serving as the baccalaureate origins of Black students who go on to pursue (and receive) doctorates in science and engineering (see Chapter 1). Other studies have documented the differential role of women's colleges as baccalaureate sources for women who receive Ph.D.s in science and engineering. Examination of doctorate records indicates the special role of other institutions for Hispanic and American Indian students who go on to pursue further study toward the doctorate in science and engineering fields. What qualities of these institutions produce supportive environments for non-traditional students in science and engineering? While such institutions may have fewer research resources, they apparently have strengths that attract, nurture, and support students in ways not yet matched by the research institutions which educate most scientists and which are generally perceived to be the trainers of choice for the next generation of scientists and engineers.

Research universities receive the lion's share of federal support for science and engineering. With the greatest human and research resources for science and engineering, they bear added responsibilities for carrying out national goals to greatly increase the participation of students from underrepresented groups. By comparing their activities and those of institutions with

a stronger and more sustained track record of support and accomplishment in this task, we hoped to find clues that could guide policy and institutional responses.

Policy Recommendations

Universities and colleges are the major recipients of federally funded research. With the dollars received they generate knowledge and train the next generation of researchers. Federally funded research is highly concentrated in a handful of higher education institutions. According to the National Science Foundation 10 universities receive 25% of federal research dollars. The 30 largest recipients receive some 50% of federal research funding. This concentration of research dollars would tend to favor these institutions as producers of talent for science and engineering.

While recognizing the importance of undergraduate research experience and exposure to a research environment in encouraging students to pursue graduate education, data suggest that students from underrepresented groups have found their baccalaureate origins elsewhere. The policy choices for those who seek to increase the presence of such students within the doctoral pool are to (1) support creation of *microenvironments* within research universities which are supportive of such students; (2) support research capability of supportive institutions; and/or (3) create links between supportive and research institutions so that students may have the best of what each set of institutions can offer.

1. Support research capability of institutions with a proven record of developing students from underrepresented groups.

Programs such as MARC (Minority Access to Research Careers) and MBRS (Minority Biomedical Research Support) of the National Institutes of Health, and Minority Research Centers of Excellence of the National Science Foundation, should be continued and expanded to enhance the research environments of institutions with proven track records in the education of students in science and engineering who are American Indian, Black, Mexican American, and Puerto Rican. Similarly, there is a need to explore the possibility of establishing similar research-focused programs for traditionally women's colleges. A program should be specifically tailored for this set of institutions as opposed to expanding the pool of eligible institutions (and increasing the pressure on existing funds) for the currently targeted programs or creating programs which are too dependent on connections being established one faculty member at a time or which subordinate the role of undergraduate institutions compared to research universities in partnership of unequals.

2. Provide scholarship support for students from underrepresented groups to encourage participation and retention in science and engineering fields.

Scholarships signal national priorities—letting the research establishment know what the federal government holds to be deeply significant to the U.S. research enterprise. When used in conjunction with program support activities, these scholarships can be an effective tool to build a cadre of talented and committed students for science and mathematics who come from underrepresented groups. Especially important are scholarships that require commitment to and build toward graduate and/or professional education in engineering and science-based fields. The presence of scholarship support has added advantages in attracting able and needy students to courses of study

which require long in-class hours of laboratory work and out-of-class hours for study—a time commitment difficult to sustain for students who must work or shoulder additional loan burdens.

3. Evaluate the effectiveness of portable and institutionally-based sources of graduate support for minority students and greatly increase the funding models that seem to be most effective in supporting the development of these students in science and engineering.

Federal and non-federal support programs should be included. Many have argued that the effectiveness of the GEM program (National Consortium for Graduate Engineering Degrees for Minorities) is due to its program structure, which balances portability, requirements for institutional commitment, and ties to the workforce. While portability gives students more choices among institutions, included among those choices are institutions from which they have a reduced chance of ever graduating—those with weak commitment to such students, where students may be isolated, and where no faculty role models are present. Portability may also yield weak faculty commitment to students as well as failure to connect to a research team. Institutionally based support may lead to bad matches between students and their research interests or may limit student access, especially to the most highly selective institutions and departments.

4. Establish programs of graduate support for female students and those with disabilities. Monitor current support mechanisms for graduate education to ensure that students from underrepresented groups have access to research assistantship funding.

Data from the Survey of Doctorate Recipients (NSF 1990a) continue to suggest that, for many fields of science and engineering, women students are more likely than men to indicate the primary use of personal sources of support to finance their graduate education. Little is known about the current participation of students with disabilities in graduate support programs. But the weak support of higher education by rehabilitation programs would indicate that this is a serious problem. A National Science Foundation Task Force which looked specifically at programs for students with disabilities has recommended targeting students with disabilities for graduate support (NSF 1990b).

Targeted programs are still necessary to support the movement of students from underrepresented groups through the science and engineering pipeline. One can argue that the regular mechanisms for support of graduate education must be made more accessible to such students so that one day targeting may cease to be necessary. More careful monitoring should be made of the race, ethnicity, sex, citizenship, and disability status of students being supported through assistantships tied to research grants.

5. Access to programs and institutions by underrepresented groups must become a major criterion to determine merit in evaluating proposals for establishing major research centers or for renewing contracts or cooperative agreements for existing centers.

As the demand grows for research funds, proposing institutions should be required to demonstrate that major federal research investments will be accessible to students from all groups through pro-active efforts to include minority, female, and disabled students among those participating in research and training activities.

6. Support enhanced collection of data by colleges and universities to provide indicators of participation in science and engineering by race/ethnicity, sex, and disability status.

Determining the health of science and engineering in the United States depends on being able to assess the flow of people through the pipeline for these fields. Current levels of data collection are not adequate to do this. Especially lacking is information on the retention of students in science and engineering, especially by race/ethnicity and sex. Graduation rates for student athletes have been published for specific schools, by sex, and minority group membership. This should be considered as a possible model for reporting science and engineering enrollment and graduation data. Some indication is also needed as to the amount of science and mathematics students take *beyond that which is required* as a measure of the attractiveness and effectiveness of introductory and non-major courses in these fields.

The notion of retention rate in graduate education in science and engineering does not appear to operate, but the conversion of graduate school enrollees to graduates is an important indicator of the "health of science." More study is needed on this missing information to assess the status of graduate education. Without it there is little hope of even identifying, much less plugging, these leaks from the pipeline.

7. The current status of women, minority, and disabled faculty, and historical evidence of progress in attracting and advancing such individuals should be used as a criterion in determining support for major research centers and traineeship programs in departments, programs and institutions.

The marginal positions of these groups within faculties was noted in the data obtained in the study, especially the increased likelihood of members of these underrepresented groups to appear in part-time and off-line positions. Data indicating dependence of programs for women on volunteer activities by women faculty suggest that these individuals are carrying an additional responsibility to recruit, retain and nurture women students that is not being borne by male colleagues. The structure of the reward/incentive system, especially in research-intensive institutions, would jeopardize the promotion, tenure, and further advancement of these female faculty members. Federal investment supporting research along with infrastructure development, talent production, and increased participation by underrepresented groups, should be placed in institutions that value all of these elements as evidenced by their use in tenure and promotion decisions. The status of faculty and students from underrepresented groups, a strong indicator of institutional commitment, should be used along with scientific merit in making major funding decisions.

8. Provide federal support for a range of program structures to address underrepresentation in science and engineering at undergraduate and graduate levels. Disseminate successful efforts and shift the emphasis of funding from isolated projects to institution-wide, coordinated efforts which can affect structural change.

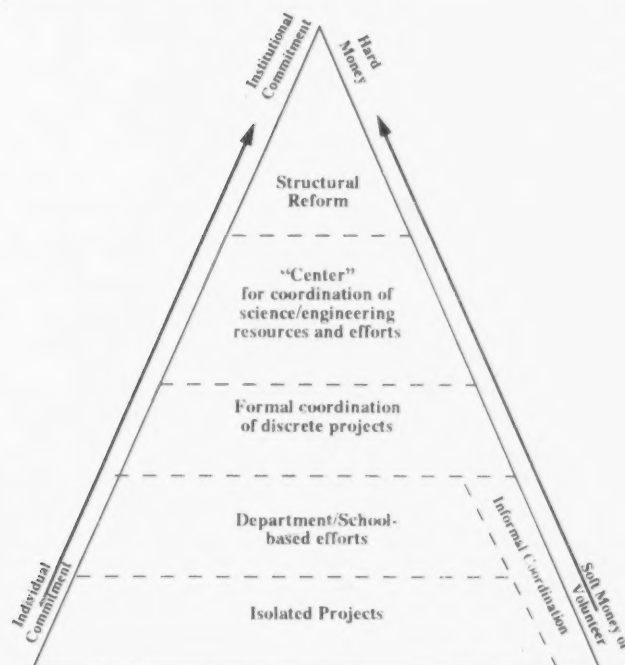
The projects identified in this study range from a large number initiated by individuals working in relative isolation within departments or programs, to a smaller number of comprehensive efforts within schools of engineering or science centers within colleges.

Even case studies of institutions with strong positive program responses confirm the absence of models of structural reform within colleges and universities to support the participation of underrepresented groups.

Based on project descriptions and case studies, we developed a model for the evolution of intervention programs that were identified among the institutions in this study. Five levels of program development were defined.

1. *Isolated projects* were numerous, and involved the commitment of individuals to address particular barriers to participation. These projects were often not connected to any other efforts and relied on soft money or volunteer activity for their continuation.

Model for the Evolution of Intervention Programs



2. In other instances, *individual schools or departments* undertook activities to address their own particular problems, such as high failure rates in calculus. These activities had little or no connection to other efforts in the institution, and addressed only a small part of the overall system of problems which minority, women, and disabled students face.
3. At the next level were *formalized, coordinated program activities* in one part of the institution, such as a college of engineering, where recruitment and retention of female and minority students was coordinated through the office of the dean. Funding for these programs included external grants but relied increasingly on hard dollars from the institution. Most frequently missing from these programs were ties necessary to modify required introductory courses in the sciences and mathematics. There was often reliance on programs to equip the students to survive instead of also taking on the issue of the quality and cultivation aspects of courses.
4. In a few instances, institutions created *centers* for the coordination of large parts of the process of recruiting, retaining, tracking, and advancing students to graduate education. One of the most notable examples of this is the Comprehensive Regional Center for

Minorities in Puerto Rico. In this case, the center formed an organizational overlay to the mission of the institution to educate particular groups of underrepresented students.

5. Not found among any of the institutions was a model of *structural reform* where the structure of courses, pedagogical techniques, institutional climate and system for recruitment and retention co-existed with a supportive administrative structure, that is, where the regular support of departments and programs provides mechanisms to support the achievement of all students committed to education in science and engineering.

When the President and the nation's governors met in Charlottesville in 1989 at the Education Summit, they agreed that improvement of science and mathematics achievement should be one of the six goals for educational reform in the United States. Objective 3 of the science and mathematics goal (Goal 4) of the Education Summit report, articulates the national imperative to promote wider participation in science and engineering, not just for the sake of underrepresented groups but for the good of the country. It therefore follows that federal money invested in the United States' research enterprise must support and enhance the achievement of these goals.

A 1991 report from the Office of Technology Assessment, in describing the process for developing a balanced research portfolio, states:

...(A)lthough scientific merit and mission relevance must always be the chief criteria used to judge a research area or agency program's potential worth, they cannot always be the *sole* criteria. In particular, the application of criteria that augment scientific merit — which represent *today's* judgments of quality — would help meet *tomorrow's* objectives of research investment. (P. 15)

Broadly stated, there are two such criteria: strengthening education and human resources at all stages of study (for example, increasing the diversity and versatility of participants), and building regional and institutional capacity. The R&D enterprise depends for its vitality and continued existence on its ability to produce knowledge and support infrastructure development. Expanding the base of talent for science and engineering is an embedded rather than an ancillary part of federal investment. ■

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Appendixes:

**A – U.S. Higher Education Institutions
Surveyed**

B – Case Study Protocol

Appendix A—U.S. Higher Education Institutions Surveyed

(*denotes those institutions which chose to participate in the study)

ALABAMA

- *Alabama Agricultural and Mechanical University
Normal, AL
- Alabama Christian College
Montgomery, AL
- *Alabama State University
Montgomery, AL
- *Auburn University
Main Campus Auburn, AL
- Livingston University
Livingston, AL
- Miles College
Birmingham, AL
- Oakwood College
Huntsville, AL
- Selma University
Selma, AL
- *Stillman College
Tuscaloosa, AL
- Talladega College
Talladega, AL
- Troy State University
Main Campus Troy, AL
- *Troy State University at Montgomery
Montgomery, AL
- *Tuskegee Institute
Tuskegee Institute, AL
- *University of Alabama at Birmingham
Birmingham, AL
- University of Alabama at Huntsville
Huntsville, AL
- University of Alabama at University
University, AL
- University of South Alabama
Mobile, AL

ALASKA

- *Sheldon Jackson College
Sitka, AK
- *University of Alaska—Anchorage
Anchorage, AK
- *University of Alaska—Fairbanks
Fairbanks, AK

ARIZONA

- American Indian Bible College
Phoenix, AZ
- *Arizona State University
Tempe, AZ
- *Northern Arizona University
Flagstaff, AZ
- *University of Arizona—Tucson
Tucson, AZ

ARKANSAS

- Arkansas Baptist College
Little Rock, AR
- Philander-Smith College
Little Rock, AR
- *Southern Arkansas University—Main Campus
Magnolia, AR
- *University of Arkansas—Fayetteville
Fayetteville, AR
- *University of Arkansas at Little Rock
Little Rock, AR
- *University of Arkansas at Monticello
Monticello, AR
- University of Arkansas at Pine Bluff
Pine Bluff, AR

CALIFORNIA

California Baptist College
Riverside, CA

*California Institute of
Technology
Pasadena, CA

*California Polytechnical
State University—
San Luis Obispo
San Luis Obispo, CA

*California State
Polytechnic University
Pomona, CA

*California State University—
Chico
Chico, CA

*California State University—
Dominguez Hills
Carson, CA

California State University—
Fresno
Fresno, CA

*California State University—
Fullerton
Fullerton, CA

*California State University—
Long Beach
Long Beach, CA

California State University—
Los Angeles
Los Angeles, CA

*California State University—
Northridge
Northridge, CA

*California State University—
Sacramento
Sacramento, CA

D-Q University
Davis, CA

DeVry Institute of Technology—
Los Angeles
City of Industry, CA

*Dominican College of
San Rafael
San Rafael, CA

Harvey Mudd College
Claremont, CA

*Loyola Marymount University
Los Angeles, CA

Northrop University
Los Angeles, CA

Patten College
Oakland, CA

*Pomona College
Claremont, CA

Saint John's College
Camarillo, CA

*San Diego State University
San Diego, CA

*San Francisco State University
San Francisco, CA

*San Jose State University
San Jose, CA

*Stanford University
Stanford, CA

*University of California—
Berkeley
Berkeley, CA

*University of California—
Davis
Davis, CA

University of California—
Irvine
Irvine, CA

*University of California—
Los Angeles
Los Angeles, CA

University of California—
San Diego
La Jolla, CA

University of California—
San Francisco
San Francisco, CA

University of California—
Santa Barbara
Santa Barbara, CA

*University of California—
Santa Cruz
Santa Cruz, CA

University of Santa Clara
Santa Clara, CA

*University of Southern California
Los Angeles, CA

*University of the Pacific
Stockton, CA

University of West Los Angeles
Los Angeles, CA

West Coast Christian College
Fresno, CA

COLORADO

- Adams State College
Alamosa, CO
- Colorado College
Colorado Springs, CO
- *Colorado School of Mines
Golden, CO
- *Colorado State University
Fort Collins, CO
- Fort Lewis College
Durango, CO
- University of Colorado-
Boulder
Boulder, CO
- University of Colorado-
Denver
Denver, CO
- University of Denver
Denver, CO
- *University of Northern Colorado
Greeley, CO

CONNECTICUT

- Trinity College
Hartford, CT
- U. S. Coast Guard Academy
New London, CT
- *University of Bridgeport
Bridgeport, CT
- *University of Connecticut-
Storrs
Storrs, CT
- *University of Hartford
West Hartford, CT
- Wesleyan University
Middletown, CT
- *Yale University
New Haven, CT

DISTRICT OF COLUMBIA

- *American University
Washington, DC
- *Catholic University of America
Washington, DC
- Gallaudet College
Washington, DC
- *George Washington University
Washington, DC
- *Howard University
Washington, DC

- *Trinity College
Washington, DC
- *University of the
District of Columbia
Washington, DC

DELAWARE

- Delaware State College
Dover, DE
- *University of Delaware
Newark, DE
- *Wilmington College
New Castle, DE

FLORIDA

- *Bethune-Cookman College
Daytona Beach, FL
- Edward Waters College
Jacksonville, FL
- *Florida Agricultural &
Mechanical University
Tallahassee, FL
- *Florida Atlantic University
Boca Raton, FL
- *Florida Institute of Technology
Melbourne, FL
- *Florida International University
Miami, FL
- Florida Memorial College
Miami, FL
- *Florida State University
Tallahassee, FL
- Jones College-
Jacksonville
Jacksonville, FL
- St. Thomas of Villanova University
Miami, FL
- *University of Central Florida
Orlando, FL
- *University of Florida-
Gainesville
Gainesville, FL
- University of Miami
Coral Gables, FL
- University of South Florida
Tampa, FL

GEORGIA

- *Albany State College
Albany, GA
- Atlanta University
Atlanta, GA

Clark College
Atlanta, GA
DeVry Institute of Technology
Decatur, GA
Fort Valley State College
Fort Valley, GA
*Georgia Institute of Technology
Atlanta, GA
Morehouse College
Atlanta, GA
Morris Brown College
Atlanta, GA
*Paine College
Augusta, GA
Savannah State College
Savannah, GA
*Spelman College
Atlanta, GA
University of Georgia-
Athens
Athens, GA

HAWAII

Chaminade University of Honolulu
Honolulu, HI
Hawaii Pacific College
Honolulu, HI
*University of Hawaii at Manoa
Honolulu, HI

IDAHO

*Boise State University
Boise, ID
*Idaho State University
Pocatello, ID
*University of Idaho
Moscow, ID

ILLINOIS

*Bradley University
Peoria, IL
Chicago State University
Chicago, IL
DeVry Institute of Technology-
Chicago
Chicago, IL
*Illinois Institute of Technology
Chicago, IL
Kendall College
Evanston, IL
Northeastern Illinois University
Chicago, IL

*Northwestern University
Evanston, IL
Parks College of St. Louis University
Cahokia, IL
Roosevelt University
Chicago, IL
*Southern Illinois University-
Carbondale
Carbondale, IL
*Southern Illinois University-
Edwardsville
Edwardsville, IL
University of Chicago
Chicago, IL
*University of Illinois-
Chicago
Chicago, IL
*University of Illinois-
Urbana
Urbana, IL
*Western Illinois University
Macomb, IL

INDIANA

Ball State University
Muncie, IN
DePauw University
Greencastle, IN
*Indiana University-
Bloomington
Bloomington, IN
Indiana-Purdue University-
Indianapolis
Indianapolis, IN
Indiana University-
Northwest
Gary, IN
*Purdue University-
Calumet
Hammond, IN
*Purdue University-
West Lafayette
West Lafayette, IN
*Tri-State University
Angola, IN
*University of Evansville
Evansville, IN
*University of Notre Dame
Notre Dame, IN

IOWA

- *Drake University
Des Moines, IA
- Iowa State University of
Science and Technology
Ames, IA
- University of Iowa
Iowa City, IA
- *University of Northern Iowa
Cedar Falls, IA

KANSAS

- Kansas State University of
Agriculture and Applied Science
Manhattan, KS
- *University of Kansas
Lawrence
Lawrence, KS
- Wichita State University
Wichita, KS

KENTUCKY

- *Kentucky State University
Frankfort, KY
- *University of Kentucky—
Lexington
Lexington, KY
- *University of Louisville
Louisville, KY

LOUISIANA

- Dillard University
New Orleans, LA
- Grambling State University
Grambling, LA
- *Louisiana State University and
A & M College
Baton Rouge, LA
- Louisiana State University—
Shreveport
Shreveport, LA
- McNeese State University
Lake Charles, LA
- Southern University and
A & M College—
Baton Rouge
Baton Rouge, LA
- *Southern University at New Orleans
New Orleans, LA
- University of New Orleans
New Orleans, LA

- *University of Southwestern Louisiana
Lafayette, LA
- Xavier University of Louisiana
New Orleans, LA

MAINE

- *Bowdoin College
Brunswick, ME
- *Colby College
Waterville, ME
- University of Maine at Orono
Orono, ME

MARYLAND

- Bowie State College
Bowie, MD
- Columbia Union College
Takoma Park, MD
- *Coppin State College
Baltimore, MD
- Frostburg State University
Frostburg, MD
- Hood College
Frederick, MD
- *Johns Hopkins University
Baltimore, MD
- Morgan State University
Baltimore, MD
- *U. S. Naval Academy
Annapolis, MD
- *University of Maryland—
College Park
College Park, MD
- *University of Maryland—
Eastern Shore
Princess Anne, MD

MASSACHUSETTS

- *Amherst College
Amherst, MA
- Atlantic Union College
South Lancaster, MA
- *Boston College
Chestnut Hill, MA
- *Boston University
Boston, MA
- *Brandeis University
Waltham, MA
- *Hampshire College
Amherst, MA
- *Harvard University
Cambridge, MA

Massachusetts Institute of
Technology
Cambridge, MA
Mount Holyoke College
South Hadley, MA
*Northeastern University
Boston, MA
Radcliffe College
Cambridge, MA
*Smith College
Northampton, MA
Southeastern Massachusetts
University
North Dartmouth, MA
Tufts University
Medford, MA
*University of Lowell
Lowell, MA
*University of Massachusetts
Amherst
Amherst, MA
*Wellesley College
Wellesley, MA
*Wentworth Institute of Technology
Boston, MA
*Wheaton College
Norton, MA
Williams College
Williamstown, MA
*Worcester Polytechnic Institute
Worcester, MA

MICHIGAN

*GMI Engineering Management
Institute
Flint, MI
*Jordan College
Cedar Springs, MI
*Kalamazoo College
Kalamazoo, MI
Lawrence Institute of Technology
Southfield, MI
Marygrove College
Detroit, MI
Mercy College of Detroit
Detroit, MI
Michigan Christian College
Rochester, MI
*Michigan State University—
East Lansing
East Lansing, MI

*Michigan Technological University
Houghton, MI
*Oakland University
Rochester, MI
*Saginaw Valley State College
University Center, MI
University of Detroit
Detroit, MI
*University of Michigan—
Ann Arbor
Ann Arbor, MI
*University of Michigan
Dearborn, MI
*Wayne State University
Detroit, MI
*Western Michigan University
Kalamazoo, MI

MINNESOTA

*College of Saint Catherine
Saint Paul, MN
*College of Saint Scholastica
Duluth, MN
*Mankato State University
Mankato, MN
*Saint Olaf College
Northfield, MN
*University of Minnesota—
Minneapolis/St. Paul
Minneapolis, MN

MISSISSIPPI

Alcorn State University
Lorman, MS
*Jackson State University
Jackson, MS
*Mississippi State University
Mississippi State, MS
Mississippi Valley State University
Itta Bena, MS
Rust College
Holly Springs, MS
Tougaloo College
Tougaloo, MS
*University of Mississippi
Main Campus
University, MS
William Carey College
Hattiesburg, MS

MISSOURI

- Lincoln University
Jefferson City, MO
- *Southeast Missouri State University
Cape Girardeau, MO
- University of Missouri–
Columbia
Columbia, MO
- *University of Missouri–
Kansas City
Kansas City, MO
- University of Missouri–
Rolla
Rolla, MO
- *University of Missouri
Saint Louis, MO
- Washington University
Saint Louis, MO

MONTANA

- Eastern Montana College
Billings, MT
- Montana College of
Mineral Science & Technology
Butte, MT
- Montana State University
Bozeman, MT
- *Rocky Mountain College
Billings, MT
- *University of Montana
Missoula, MT

NEBRASKA

- Creighton University
Omaha, NE
- *University of Nebraska–
Lincoln
Lincoln, NE
- *University of Nebraska–
Omaha
Omaha, NE

NEVADA

- Sierra Nevada College
Incline Village, NV
- University of Nevada
Las Vegas
Las Vegas, NV
- *University of Nevada
Reno
Reno, NV

NEW HAMPSHIRE

- *Dartmouth College
Hanover, NH
- New Hampshire College
Manchester, NH
- University of New Hampshire
Durham, NH

NEW JERSEY

- *Bloomfield College
Bloomfield, NJ
- *Farleigh-Dickinson University–
Teaneck
Teaneck, NJ
- *New Jersey Institute of Technology
Newark, NJ
- *Princeton University
Princeton, NJ
- Rutgers University Camden College
of Arts & Sciences
Camden, NJ
- Rutgers The State University of New
Jersey
New Brunswick, NJ
- Rutgers
The State University of New Jersey
Newark, NJ
- *Stevens Institute of Technology
Hoboken, NJ
- Trenton State College
Trenton, NJ

NEW MEXICO

- *College of Santa Fe
Santa Fe, NM
- *New Mexico Highlands University
Las Vegas, NM
- New Mexico Institute of
Mining and Technology
Socorro, NM
- New Mexico State University
La Cruces, NM
- *University of New Mexico
Albuquerque, NM
- Western New Mexico University
Silver City, NM

NEW YORK

- *Alfred University
Alfred, NY
- Barnard College
New York, NY

- *Clarkson University
Potsdam, NY
 - College of New Rochelle
New Rochelle, NY
 - *Columbia University
Main Division
New York, NY
 - Cooper Union
New York, NY
 - *Cornell University
Ithaca, NY
 - *Cornell University-
Brooklyn College
Brooklyn, NY
 - *Cornell University-
City College
New York, NY
 - *Cornell University-
Hunter College
New York, NY
 - Cornell University-
Queens College
Flushing, NY
 - *Cornell University-
York College
Jamaica, NY
 - Fordham University
Bronx, NY
 - Hofstra University
Hempstead, NY
 - *Long Island University-
Brooklyn Campus
Brooklyn, NY
 - Manhattan College
Riverdale, NY
 - Medaille College
Buffalo, NY
 - *New York Institute of Technology-
Main Campus
Old Westbury, NY
 - *New York University
New York, NY
 - Polytechnic Institute of New York
Brooklyn, NY
 - Pratt Institute
Brooklyn, NY
 - Rensselaer Polytechnic Institute
Troy, NY
 - *Rochester Institute of Technology
and National Technical Institute
for the Deaf
Rochester, NY
 - Saint Francis College
Brooklyn, NY
 - *Saint Joseph's College-
Main Campus
Brooklyn, NY
 - Sarah Lawrence College
Bronxville, NY
 - Skidmore College
Saratoga Springs, NY
 - *State University of New York-
Albany
Albany, NY
 - *State University of New York-
Buffalo
Buffalo, NY
 - State University of New York-
Oswego
Oswego, NY
 - *State University of New York-
Stony Brook
Stony Brook, NY
 - *State University of New York at
Old Westbury
Old Westbury, NY
 - State University of New York College
of Technology at Utica
Rome
Utica, NY
 - *State University of New York
Maritime College
Bronx, NY
 - *Syracuse University
Syracuse, NY
 - Touro College
New York, NY
 - *U. S. Merchant Marine Academy
Kings Point, NY
 - *University of Rochester
Rochester, NY
 - Vassar College
Poughkeepsie, NY
- NORTH CAROLINA**
- Appalachian State University
Boone, NC
 - *Bennett College
Greensboro, NC
 - *Duke University
Durham, NC

Elizabeth City State University
Elizabeth City, NC
Fayetteville State University
Fayetteville, NC
*Johnson C. Smith College
Charlotte, NC
Livingston College
Salisbury, NC
*North Carolina A and T
State University
Greensboro, NC
*North Carolina Central
Durham, NC
*North Carolina State University—
Raleigh
Raleigh, NC
Pembroke State University
Pembroke, NC
Saint Andrews Presbyterian College
Laurinburg, NC
Saint Augustine's College
Raleigh, NC
Salem College
Winston-Salem, NC
Shaw University
Raleigh, NC
University of North Carolina at
Charlotte
Charlotte, NC
*University of North Carolina at
Chapel Hill
Chapel Hill, NC
University of North Carolina at
Greensboro
Greensboro, NC
*Winston-Salem State University
Winston-Salem, NC

NORTH DAKOTA

*Minot State College
Minot, ND
*North Dakota State University
Main Campus
Fargo, ND
University of North Dakota
Main Campus
Grand Forks, ND

OHIO

Antioch University
Yellow Springs, OH

*Bowling Green State University
Main Campus
Bowling Green, OH
*Case Western Reserve University
Cleveland, OH
Central State University
Wilberforce, OH
*Cleveland State University
Cleveland, OH
*Denison University
Granville, OH
DeVry Institute of Technology—
Columbus
Columbus, OH
*Franklin University
Columbus, OH
*Muskingum College
New Concord, OH
Notre Dame College
Cleveland, OH
*Oberlin College
Oberlin, OH
Ohio Northern University
Ada, OH
*Ohio State University—
Columbus
Columbus, OH
*Ohio University
Main Campus
Athens, OH
*University of Cincinnati
Main Campus
Cincinnati, OH
*University of Dayton
Dayton, OH
*University of Toledo
Toledo, OH
Urbana College
Urbana, OH
*Wilberforce University
Wilberforce, OH
Wright State University
Dayton, OH
*Youngstown State University
Youngstown, OH

OKLAHOMA

Langston University
Langston, OK
Northeastern Oklahoma State
University
Tahlequah, OK

- *Oklahoma State University-
Stillwater
Stillwater, OK
- Phillips University
Enid, OK
- *University of Oklahoma-
Norman Campus
Norman, OK
- *University of Tulsa
Tulsa, OK

OREGON

- *Linfield College
McMinnville, OR
- *Oregon Institute of Technology
Klamath Falls, OR
- *Oregon State University
Corvallis, OR
- *Portland State University
Portland, OR
- Reed College
Portland, OR
- University of Oregon
Eugene, OR
- Warner Pacific College
Portland, OR

PENNSYLVANIA

- Bryn Mawr College
Bryn Mawr, PA
- *Bucknell University
Lewisburg, PA
- Carnegie-Mellon University
Pittsburgh, PA
- *Cheyney University of Pennsylvania
Cheyney, PA
- *Drexel University
Philadelphia, PA
- *Gettysburg College
Gettysburg, PA
- Lafayette College
Easton, PA
- *Lehigh University
Bethlehem, PA
- *Lincoln University
Lincoln University, PA
- *Pennsylvania State University
University Park, PA
- *Swarthmore College
Swarthmore, PA
- Temple University
Philadelphia, PA

- University of Pennsylvania
Philadelphia, PA
- *University of Pittsburgh
Pittsburgh, PA
- University of Pittsburgh-
Johnstown
Johnstown, PA
- *Villanova University
Villanova, PA
- Widener University-
PA Campus
Chester, PA
- *Wilkes College
Wilkes-Barre, PA

PUERTO RICO

- *American College of Puerto Rico
Bayamon, PR
- Antillian College
Mayaguez, PR
- Bayamon Central University
Bayamon, PR
- Catholic University of Puerto Rico
Ponce, PR
- Colegio Universitario Metropolitano
Rio Piedras, PR
- Electronic Data Processing College of
Puerto Rico
Hato Rey, PR
- *Inter-American University of
Puerto Rico-
Arecibo Branch
Arecibo, PR
- Inter-American University of
Puerto Rico-
Metro Campus
Hato Rey, PR
- *Inter-American University of
Puerto Rico-
San German Campus
San German, PR
- *Rayamon Technological Union
College of the University of
Puerto Rico
Bayamon, PR
- Universidad del Turabo
Gurabo, PR
- *Universidad Politecnica
de Puerto Rico
Hato Rey, PR

- *University of Puerto Rico
Arecibo Technological
University College
Arecibo, PR
- *University of Puerto Rico
Cayey University College
Cayey, PR
- *University of Puerto Rico
Humacao University College
Humacao, PR
- *University of Puerto Rico
Mayaguez
Mayaguez, PR
- *University of Puerto Rico
Medical Sciences Campus
San Juan, PR
- *University of Puerto Rico
Ponce Technological University
Ponce, PR
- *University of Puerto Rico—
Rio Piedras
Rio Piedras, PR
- *University of the Sacred Heart
Santurce, PR

RHODE ISLAND

- Brown University
Providence, RI
- Rhode Island College
Providence, RI
- University of Rhode Island
Kingston, RI

SOUTH CAROLINA

- Allen University
Columbia, SC
- Baptist College at Charleston
Charleston, SC
- Benedict College
Columbia, SC
- *Claflin College
Orangeburg, SC
- *Clemson University
Clemson, SC
- Columbia College
Columbia, SC
- Morris College
Sumter, SC
- *South Carolina State College
Orangeburg, SC

- *University of South Carolina at
Columbia
Columbia, SC

SOUTH DAKOTA

- Augustana College
Sioux Falls, SD
- Sinte Gleska College
Rosebud, SD
- *South Dakota School of
Mines & Technology
Rapid City, SD
- South Dakota State University
Brookings, SD

TENNESSEE

- *Christian Brothers College
Memphis, TN
- Fisk University
Nashville, TN
- Knoxville College
Knoxville, TN
- Le Moyne-Owen College
Memphis, TN
- *Memphis State University
Memphis, TN
- Tennessee State University
Nashville, TN
- *Tennessee Technological University
Cookeville, TN
- University of Tennessee—
Chattanooga
Chattanooga, TN
- University of Tennessee—
Knoxville
Knoxville, TN
- *Vanderbilt University
Nashville, TN

TEXAS

- Bishop College
Dallas, TX
- Corpus Christi State University
Corpus Christi, TX
- *DeVry Institute of Technology—
Irving
Irving, TX
- Incarnate Word College
San Antonio, TX
- Jarvis Christian College
Hawkins, TX

- *Lamar University
Beaumont, TX
- *Our Lady of the Lake University
San Antonio, TX
- Pan American University
Edinburg, TX
- *Prairie View A & M University
Prairie View, TX
- Rice University
Houston, TX
- *Saint Edward's University
Austin, TX
- Saint Mary's University of
San Antonio
San Antonio, TX
- Schreiner College
Kerrville, TX
- Southern Methodist University
Dallas, TX
- *Sul Ross State University
Alpine, TX
- *Texas A & I University
Main Campus
Kingsville, TX
- *Texas A & M University
College Station, *TX*
- Texas College
Tyler, TX
- *Texas Southern University
Houston, TX
- *Texas Technological University
Lubbock, TX
- Trinity University
San Antonio, TX
- University of Houston-
Downtown
Houston, TX
- University of Houston-
University Park
Houston, TX
- *University of Texas at Arlington
Arlington, TX
- *University of Texas at Austin
Austin, TX
- *University of Texas at El Paso
El Paso, TX
- *University of Texas at San Antonio
San Antonio, TX
- Wiley College
Marshall, TX

UTAH

- *Brigham Young University
Provo, UT
- *University of Utah
Salt Lake City, UT
- Utah State University
Logan, UT
- *Weber State College
Ogden, UT

VIRGIN ISLANDS

- College of the Virgin Islands
Kingshill, VI
- College of the Virgin Islands
St. Thomas, VI

VIRGINIA

- Clinch Valley College of the
University of Virginia
Wise, VA
- *College of William and Mary
Williamsburg, VA
- Hampton University
Hampton, VA
- *Old Dominion University
Norfolk, VA
- Norfolk State University
Norfolk, VA
- St Paul's College
Lawrenceville, VA
- *Sweet Briar College
Sweet Briar, VA
- University of Virginia
Charlottesville, VA
- *Virginia Commonwealth University
Main campus
Richmond, VA
- *Virginia Polytechnical Institute and
State University
Blacksburg, VA
- *Virginia State University
Petersburg, VA
- Virginia Union University
Richmond, VA

VERMONT

- *Bennington College
Bennington, VT
- College of St. Joseph the Provider
Rutland, VT

- *University of Vermont &
State Agricultural College
Burlington, VT

WASHINGTON

- *Central Washington University
Ellensburg, WA
- Evergreen State College
Olympia, WA
- *Saint Martin's College
Lacey, WA
- *Seattle University
Seattle, WA
- *University of Washington—
Seattle
Seattle, WA
- Walla Walla College
College Place, WA
- *Washington State University
Pullman, WA

WEST VIRGINIA

- *Marshall University
Huntington, WV
- *West Virginia Institute of Technology
Montgomery, WV
- West Virginia State College
Institute, WV
- *West Virginia University
Morgantown, WV

WISCONSIN

- Alverno College
Milwaukee, WI
- *Edgewood College
Madison, WI
- *Marquette University
Milwaukee, WI
- Milwaukee School of Engineering
Milwaukee, WI
- *University of Wisconsin—
La Crosse
La Crosse, WI
- *University of Wisconsin—
Madison
Madison, WI
- University of Wisconsin—
Milwaukee
Milwaukee, WI
- *University of Wisconsin—
Platteville
Platteville, WI
- *University of Wisconsin—
Stout
Menomonie, WI
- *University of Wisconsin—
Whitewater
Whitewater, WI

WYOMING

- University of Wyoming
Laramie, WY

Appendix B—Case Study Protocol

The surveys of presidents and chancellors, of programs for women and minorities, and of disabled student services offices allowed us to select and examine specific information on how institutions recruit and retain female students, minority students and students with physical disabilities in science and engineering. However, as detailed in previous chapters, the factors that combine to attract students to a particular institution, foster their achievements there, and promote their continued enrollment and ultimate graduation are diverse and complex. Due to constraints in length and in complexity, surveys can only sample some of these factors; many are either unknown or unexplored.

In addition, it is difficult for written surveys to clarify the interaction among these factors. For example, low expectations or discriminatory behavior by a key *gatekeeper* (such as an academic advisor or faculty member who teaches a required introductory course) could effectively block the progress of students with physical disabilities through their science curriculum, despite strong support from top administration. Likewise, high expectations and a supportive atmosphere among faculty and advisors can interact to provide students with support and services that would allow them to persist despite administrative barriers that might be encountered. Teasing out these types of interactions that promote or inhibit the recruitment and retention of students who are female, minority or physically disabled required a closer and more interactive examination of the institution.

To understand how different types of institutions create a supportive atmosphere, a series of case studies was conducted at selected institutions. Additional details concerning the purpose of the case studies and the selection of case study institutions are provided in Chapter 5.

Notification of Case Study Institutions

A number of contacts had been made at each institution prior to its selection for case study. Eligible institutions had completed the "Survey of Presidents and Chancellors." That survey provided the names of contact persons who directed programs or services which were involved in the recruitment and retention of women and minorities in science and engineering or programs to assist students with physical disabilities. As described in Chapter 1, each of these contact persons was sent a copy of either: "Survey 2a: Programs for Women and Minorities at Selected Institutions of Higher Education;" or "Survey 2b: Programs and Services for Physically Disabled Students at Selected Institutions of Higher Education." Each of the three surveys asked about the institution's interest in participating in the case study phase of the study.

Case study institutions were notified of their selection by letters to the president or chancellor and to each of the contact persons provided in the surveys. These letters also served as a letter of introduction for the individual case study researchers.

Case Study Procedures

Case study researchers were selected for their previous experience in higher education research and, specifically, in case study methodology. Each researcher received a detailed case study protocol designed specifically for this study according to guidelines in Yin (1989). This protocol provided:

- Background information on factors related to recruitment and retention of science and engineering students who are female, minority, and/or have physical disabilities
- Detailed purposes of the case study component
- Field procedures for accessing case study sites
- Specific interview protocols for various administrators, program directors, faculty members, and students
- A detailed format for the case study report

This protocol was reviewed by each researcher and discussed with the project director.

In addition to the protocol, each researcher received copies of all completed surveys from each institution and all supporting material sent by either the president or chancellor's office or the individual program directors.

Following the notification of selection and letters of introduction sent by the project director, each case study researcher telephoned selected contact persons to discuss possible site visit dates and persons to interview. Subsequently, each researcher set up a two-day interview schedule with administrators, faculty members, and program contact persons. Researchers were provided with guidelines for the selection of interviewees during the site visit (Figure B.1). However, the actual selection of interviewees was left to the discretion of the researcher. These interviews were guided by, but not limited to, the interview protocols provided in the case study protocol. Interviews were audiotaped at the discretion of the case study researcher and permission of the interviewee.

Figure B.1 Case Study Protocol Guidelines for Selection of Interview Subjects

1. In order to get an overview of how the institution perceives science/engineering pipeline issues and of their overall approach, interview at least two of the following:

- Director of admissions;
- Dean of the graduate school; and
- Dean of the school of science and/or engineering (or head of the science department, if a smaller institution).

2. If the institution has specific targeted programs (such as women in engineering programs or minority science or engineering recruitment programs), include interviews with as many program directors as possible. If there is an extensive list, prioritize programs in the following order:

- programs which specifically target both science or engineering and one or more of the target populations;
- programs which specifically target either science/engineering or one or more of the target populations; and
- programs which are not targeted specifically at science/engineering or the target populations but which may have special recruitment or retention efforts (for example, admissions offices).

For each program, try to schedule a brief interview (or a group interview) with both the program/service director and a few program participants. These participants may be students involved in a recruitment or retention program or they may be faculty involved in a faculty recruitment program.

3. If the institution does not have specific targeted programs (such as women in engineering programs or minority science or engineering recruitment programs), try to include interviews with those offices and services at the institution which:

- specifically target science or engineering; or
- are critical in students' navigation of the higher education system (such as admissions, financial aid, administrators of the schools of science or engineering, director of minority or women's affairs, or science or engineering counselor).

Case Study Reports

Following the case study site visit, researchers examined supplementary information provided by the case study institutions and prepared individual case study reports. Personnel at each case study institution had an opportunity to review and comment on the case study report. The remainder of this appendix describes the content of each study.

In each case study report, researchers were asked to include information on four broad topics: institutional characteristics; perceptions of the science and engineering pipeline; institutional approaches; and conclusions. Each of these areas is discussed below.

Institutional Characteristics

This portion of the case studies provides an overview of the institution—those characteristics that make the institution similar to other higher education institutions and those that make it unique. This information may include:

1. The geographic location of the institution and the type of community in which it is located
2. The size of the institution in terms of numbers of undergraduate and graduate students and faculty
3. The composition of the student body in terms of race, sex, socioeconomic status, and local, in-state, or out-of-state home towns
4. The general structure of the institution (for example, is there a graduate school? Are there schools or departments of science or engineering?)
5. The types of degrees offered through the graduate and undergraduate schools, particularly in science and engineering
6. Other pertinent institutional characteristics

Perceptions of the Science and Engineering Pipeline

This section in the case studies describes how the persons interviewed perceived the national need for scientists and engineers, and how they interpreted that need in terms of their own institution's production of trained scientific and engineering personnel. Some questions that the researchers considered included:

- Were interviewees aware of the predicted national need for increasing the production of scientists and engineers? Was this awareness consistent among both administration and program personnel?
- How did interviewees perceive the role of women, minorities, and persons with physical disabilities in filling the predicted gap in the science and engineering workforce? Again, were these perceptions consistent among those interviewed? Did interviewees express greater concern about particular target groups?
- How did interviewees translate this national picture into initiatives and goals for their own institution? Were the answers of administrators consistent with those of program directors? With those of program participants?

Institutional Approaches

This section discusses how the institution attempts to increase the participation of the target groups in science and engineering at the undergraduate, graduate, and faculty levels. Perspectives are provided on all three target groups, and from different institutional levels—administration, program director, faculty, and program participant—where possible. Brief descriptions are included of individual program efforts, level of coordination of effort among

individual departments, programs, or services, and administration efforts. Researchers also discuss both interview comments and their own perceptions of how effective these efforts have been. Some questions researchers considered were:

- How do the administrators and program personnel perceive the effectiveness of the institution's approach, in general, and of individual programs? Do program participants agree?
- Is there consistency among administrators, program directors, and participants as to the goals of individual programs and of the institutional approach, as a whole?
- How have individual programs been evaluated? Has any evaluation been done of the institution's efforts as a whole? What were the conclusions of those evaluations?
- Is there consistent support for individual programs from the administrative level? Is the same kind of support there for coordination of the institutional effort as a whole? How did that support contribute to the success of these efforts?
- What are the major strengths of this institution's approach? What are the weaknesses?
- Does it appear that this approach will change in the future? How? Is this change a result of formative evaluation of current efforts or a response to other factors?

Conclusions

In this section, case study researchers summarize what seemed to work at the particular case study institution and what did not seem to be effective. Most importantly, they discuss whether these successes or failures are closely related to some unique characteristics of the institution (for example, the racial/ethnic group of the student body, or the geographic location), or whether aspects of their approach might be used successfully at similar or at different types of institutions. The case studies provide information about how effective strategies might be disseminated to other sites facing the same issues.

References

- Yin, R. K. 1989. *Case study research: Design and methods* (Applied Social Research Methods Series, Volume 5). Newbury Park, CA: Sage Publications.



About AAAS

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The programs and activities of the AAAS respond to a broad spectrum of scientific opportunities. In addition to its activities to strengthen school science, mathematics, and technology education, AAAS programs focus on broadening the human resource pool of scientists and engineers, shaping science and technology policy, promoting the public understanding of science, expanding scientific cooperation in global issues, defending scientific freedom, and championing high professional standards.

The AAAS Directorate for Education and Human Resources Programs seeks to improve both formal and informal education in mathematics, science, and technology at all levels; foster equal access to these fields for women, minorities, and people with disabilities; and enhance the public's understanding of all areas of science.

About the Authors

Marsha Lakes Matyas, Ph.D. is a project director in the AAAS Directorate for Education and Human Resources Programs (EHR). Dr. Matyas' work includes both studies on and development of intervention programs for science and mathematics education at the precollege, undergraduate, and postsecondary levels. She currently serves as a member of the National Academy of Science's Committee on Women in Science and Engineering.

Shirley M. Malcom, Ph.D. is the head of the Directorate for Education and Human Resources Programs at AAAS. Dr. Malcom is a nationally recognized expert in science and mathematics education policy. She currently serves on the Smithsonian Advisory Council, the board of the National Center on Education and the Economy, and the National Science Foundation Informal Science Education review panel.

Yolanda S. George is Program Director of AAAS-EHR. She directs multi-year science, mathematics, and computer education programs for minorities, women, and persons with disabilities. In addition, she provides technical assistance to school districts, community-based organizations, colleges and universities, and science museums that want to develop or expand science and mathematics programs for underrepresented groups.

Virginia S. Stern directs projects on science, technology and disability for the AAAS-EHR. She recently served on both the National Science Foundation Task Force on Disability Policy and the U.S. Census Advisory Committee on the Post-Censal Survey of Americans with Disabilities.

Directorate for Education and Human Resources
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
1333 H Street, NW, Washington, DC 20005